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[UNIVERSITY OF LONDON]

# WYE COLLEGE

Department of Hop Research

## ANNUAL REPORT

1951

*Copies of this Report may be obtained, price 4/-, from the Secretary, Wye College, Nr. Ashford, Kent*

COMMONWEALTH MYCOLOGICAL INSTITUTE
12 FEB 1953

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# DEPARTMENT OF HOP RESEARCH

## Introduction

The College is again grateful to the Hops Marketing Board and to the Institute of Brewing both for the interest which the Board and the Institute have taken in its hop research work and for the substantial financial assistance granted to it by both organizations, through the Ministry of Agriculture. It may be remembered that the whole of the non-recurrent grant and 60 per cent. of the recurrent grant is shared between the Board and the Institute, the remaining 40 per cent. of the recurrent grant being contributed by the Ministry of Agriculture. The College also desires to express its appreciation of the co-operation it continues to receive from co-workers at East Malling Research Station and for the assistance so readily granted by the Brewing Industry Research Foundation.

It is felt that growers may in particular be interested in the account of the variation of the mineral content of the hop leaf as an example of the complexities which beset the field adviser in dealing with problems of hop nutrition and also in the observations on the manuring of the crop which call attention to some rather interesting new trends.

The second survey of Picking Machines has been published in some detail as many interested in the machines have expressed a desire for a detailed comparative account. It will, of course, be borne in mind that these machines are, in general, in a stage of rapid development and evolution, and it is for this reason that it is planned to continue the survey annually for a few years during which time many changes in design and some rapid developments may be expected. The College is grateful to all those who so readily co-operated in the survey.

During the present year it is hoped to complete the projected extension of the research laboratory, to make provision for a pressurized greenhouse for further breeding studies and to increase the capacity of the oast in order to deal with crops from the large number of special plots of hops now being grown on the College Farm. With the additional facilities the equipment of the department will be materially improved.

Dunstan Skilbeck,
*Principal.*

June, 1952.

# GENERAL REPORT

## THE HOP GARDENS

1951 was a somewhat difficult season for hop growing; the very wet winter was followed by a spell of cold, dry weather and this combination of conditions hindered early growth. Aphis continued their migration to the hops over a long period which necessitated frequent spraying. Although the season was generally wet Downy Mildew was not particularly troublesome during the growing period owing, presumably, to the fairly cool weather which prevailed. The weather in late August and September was, however, favourable to the development and spread of this disease which would have been troublesome had the hops not been effectively sprayed with Bordeaux Mixture. The crop was harvested in good condition; picking was easy and the kilns were kept fully loaded. In addition to our own hops we dried the produce from over an acre of hops grown at East Malling Research Station.

*Wye Field.* Six acres of this garden, which is to be used for an experiment on the effects of different heights of wirework combined with different spacing of the plants, was planted in March, 1951, with Fuggles, John Ford Hop, Bullion Hop and Brewer's Gold. Rooted sets of Bullion and Brewer's Gold were used and these made excellent growth, some bines reaching the full height of the highest (17 ft. 3 in.) wirework. Fuggle and John Ford Hop were planted as layer cuttings which made a poor start owing to adverse weather conditions and there are several weak plants and some blanks in these varieties. A survey of these new plantings has been made so that the exact history of each hill will be recorded.

Four clonal plants of each of 39 selected Fuggle hops have been planted and in due course the best of these will be selected for further trials.

Seven plots of new seedling varieties have been grubbed and replaced with fresh selections, and the planting up of several other plots has been completed. Records have been made of the vigour and general cultural characters of the varieties and the incidence of disease. Thirty-one plots were picked and dried separately, enabling the yield to be estimated and providing material for brewing tests.

*Silks Garden.* This garden, in which varieties of hop susceptible to mosaic disease are grown, contains clones of 130 selected Goldings, the cultural characters of which have been recorded. The garden also contains experimental plots, in the varieties Early Bird, Petham Golding and Eastwell Golding, designed to study the effect of cutting the bine at picking time and the effect of stripping off the lower leaves and laterals during the growing season. Yields of green hops from these plots showed no significant difference in 1951 due to either bine cutting or leaf stripping—growth was very vigorous on all the plots.

*Nursery Garden.* The annual work of making notes on the several thousand seedlings in the Nursery Garden, and in Wye Field Nursery, was continued. During the winter several hundred plants considered to have no commercial promise were grubbed and replanted with seedlings raised from a large number of selected parents.

Samples of hops from 33 new seedling plants were collected and analysed for resin content. A number of these samples were submitted to a hop merchant and a brewer for reports on their commercial value. Special attention has been paid to seedlings having an early, or very early, season; four of these ripened in August. These early hops, if commercially satisfactory, will enable growers to extend the period of use of picking machines.

Some half-dozen new seedlings have given outstandingly high analytical results in view of the generally low level for hops this season.

## NUTRITION OF THE HOP

### Laboratory Work

Work on the improvement of methods for mineral analysis proceeds when opportunity allows. In particular the Titan yellow method for magnesium estimation has been modified so as to cut out interference by the heavy amounts of copper contamination found on hop leaves due to copper spraying. This method is now in routine use. Preliminary experiments have been made in the examination of the organic constituents of the hop plant by chromatographic methods.

### Mineral Deficiency Plots

One series of observation plots is now showing excellent development of potassium and magnesium deficiencies both singly and in combination. These plots are of particular value in

demonstrating the field symptoms of these deficiencies to Advisory Officers and serve to illustrate how confusion may arise between the two deficiencies especially when severe scorching has developed. Control of the magnesium deficiency is effectively obtained by soil applications of Epsom Salts.

A further experiment, primarily concerned with the development of potash-induced magnesium deficiency, produced symptoms of the deficiency for the first time in 1951. These symptoms were associated with an exchangeable potash content of 1·2 mg. eq./100g and an exchangeable magnesium content of 0·35 mg. eq./100g, under conditions of low nitrogen manuring. Soil applications of magnesium sulphate (as Epsom Salts) controlled the development of symptoms, as did nitrogenous top dressings. The data from this experiment is proving of value in advisory work in interpreting the results of soil analysis for " available " nutrients by quick test techniques, from the aspect of predicting the likelihood of occurrence of magnesium deficiency.

### Acidity Trials

A field trial laid down on acid Tunbridge Wells Sand soil, to study the influence of pH on hop growth has produced the unexpected result that, under the conditions of the experiment, good growth has been maintained at a pH as low as 4·5. The trial has been running for three seasons and has now been concluded. An account of this trial appears on page 24 of this Report.

In the light of the results obtained from this trial a randomized experiment has been started at Wye, in which hops are being grown in barrels in three different soil types, at four pH levels (4·5, 5·5, 6·5, 7·5) and two nutritional levels. The first year's results have shown that the best growth is obtained at pH 5·5, on all soils, while on a strongly buffered Wadhurst clay good growth has been produced even at pH 4·5. On the other two soils, one a Tunbridge Wells Sand soil and the other a brickearth from the Lower Greensand, manganese toxicity is the dominant factor affecting growth and yield at pH 4·5.

### Water and Pot Cultures

A series of water cultures was established in 1951 to study the technique of growing hops in nutrient solutions and to investigate the effect of wide variations in the levels of nitrogen, phosphorus and potassium on resin production. Starting with soft wood cuttings of the variety Brewer's Gold, sufficiently good growth

was made in the glasshouse for a useful crop of hops to be obtained with certain treatments. The nutrient levels chosen were necessarily somewhat arbitrary as the experiment was exploratory, but the best growth and yield was obtained with low phosphorus (10 ppm); the next highest yield was given by high potassium (500 ppm). The hops produced were analysed for resin content but no appreciable differences were found except in the case of the "high phosphorus" and "low potassium" treatments, both of which produced quite abnormal hops, small and under-developed.

A parallel experiment was carried out on Fuggle hops in sand culture, the plants being grown in the open. In this experiment high potassium gave the best growth and yield of hops, closely followed by low phosphorus. As in the water culture experiment, the effect on resin content was not appreciable, variation between duplicates being greater than that between treatments.

An extended series of mineral deficiency pots was run in sand culture in 1951, and colour photographs were made of the symptoms produced. It was noted in particular that the symptoms of potash deficiency in sand culture did not show a close resemblance to those found under field conditions.

### Seasonal Variation in Mineral Content of the Hop Leaf

Last year's experiment has been repeated with slight modifications and sampling was extended over a longer period (14 weeks). Two varieties, Eastwell Golding and Early Bird hops, were used. The results tend to confirm those found in 1950; calcium, magnesium and manganese accumulate in the senescent and more mature leaves, whereas potassium is generally distributed through the leaves of the plant, its concentration in a given leaf falling slightly through the season. Phosphorus and nitrogen occur in very high concentration 1·7 per cent. and 9·5 per cent. on the dry matter, respectively, in the leaves at the growing point but these levels fall as the plant reaches maturity. In comparing the results with those obtained in 1950, appreciable seasonal variation is apparent: the general tendencies of mineral movements along the bine are similar, but phosphorus and nitrogen occur in considerably higher concentrations and manganese in lower concentration than were found in 1950.

The two hop varieties behave similarly in mineral uptake except in the cases of potassium and magnesium. The Early Bird hop shows a higher potassium content and a lower magnesium content in the fully mature leaves than the Eastwell Golding;

slight variations in the soil nutritional status may have influenced this, but in the "Time of Cutting Bine" experiment a parallel difference in the mineral contents of bines of the two varieties occurs and there may be a definite varietal difference in potassium and magnesium uptake.

### Long-term Manurial Trial

This experiment was initially designed to compare the standard Wye recommendations for the manuring of hops as drawn up by Dr. Burgess, with a type of manuring often carried out by commercial growers in which excessive and unbalanced amounts of nitrogen, phosphorus and potassium are used.

The statistical layout adopted is a $2^n$ factorial design of great flexibility, allowing for the incorporation of new treatments as the experiment proceeds. This layout was recommended by the Statistical Department of East Malling Research Station as being most suitable for an experiment of this type.

The basic ("normal") treatment is 300 lb. nitrogen, 200 lb. phosphoric acid ($P_2O_5$) and 200 lb. potash ($K_2O$) per acre. These nutrients are supplied partly as dung and partly as inorganic fertilizers, the allowance made for the mineral nutrients in the dung being based on analysis. The "excess" dressings applied are 400 lb. nitrogen, 500 lb. phosphoric acid ($P_2O_5$) and 400 lb. potash ($K_2O$) per acre.

In 1951, in addition to 14 ton dung per acre the plots received 12 and 17½ cwt./acre nitro-chalk for the normal and high nitrogen treatments; 4½ and 19½ cwt./acre superphosphate for the normal and high phosphorus treatments; 1¾ and 4¾ cwt./acre muriate of potash for the normal and high potash treatments. The crop harvested from the plots was excellent and averaged 27·8 cwt./acre compared with 22 cwt./acre for the rest of the garden, treated commercially. The main treatment effects were a *depression* in yield of 1·2 cwt./acre associated with the high nitrogen treatment, an *increase* of 2·9 cwt./acre due to the high phosphorus treatment, and an *increase* of 1·9 cwt./acre with high potassium. Only the phosphorus effect was statistically significant.

The phosphorus effect is contrary to expectations and may partly be explained by the fact that the soil was initially "very low" in available phosphate, coupled with high soil fixation of applied phosphate. In addition the hops were planted only in 1949, and 1951 was the first year of full bearing, so that the effect of phosphorus on root development would be expected to be at its maximum.

Evidence gained indirectly from other experiments suggests that under some conditions the hop can grow well on a very much lower level of phosphatic manuring than is generally practised and it is noteworthy that the yield increase from the high phosphorus treatment in the present experiment has fallen appreciably in 1951 from that obtained in 1950, and may continue to fall as the level of available phosphorus is built up in the soil.

The nitrogen and potassium effects obtained are much as were expected.

Leaf samples were taken from all the plots on two occasions and one of the most interesting results shown from analysis is a significant increase in leaf calcium due to high phosphorus manuring, at both sampling dates. This may have an important influence in depressing potassium uptake by the hop, there being a significant negative correlation between the content of leaf calcium and potassium on each sampling occasion.

Other comparisons made in the experiment are presence and absence of magnesium (as Epsom Salts) and " complete inorganic " manuring *v.* " dung and inorganics ". In 1951 neither comparison gave a significant difference in yield.

## Growth of Hops under Grass

Grass was sown on plots in the early summer (May) of 1950, so that 1951 was the first season of full establishment of the swards and gave the first opportunity for making detailed records and observations on the effect of the grass on the growth of the hops. Under " ryegrass and clover " and " cocksfoot and clover " swards the hops were appreciably checked and gave a statistically significant lower yield compared with the clean cultivated plot ; it seems evident, however, that this was primarily due to faults in management, the grass at one stage being allowed to get much too long before being cut (the spring flush of growth) so that virtually a hay crop had to be taken off the plots ; and, in addition, nitrogenous manuring throughout the growing season was at too low a level, so that the hops suffered from nitrogen starvation ; this was clearly shown by the yellow-green foliage and weakened growth of the plants and was confirmed by leaf analyses. It was noteworthy, however, that a plot of S50 timothy and wild white clover, which suffered from the same faults of mismanagement, nevertheless gave growth and yield of hops equal to that on the clean cultivated plot. The timothy competed much less with the

hops than did the cocksfoot and ryegrass, and also produced a sward containing a higher proportion of wild white clover.

Extra nitrogen top dressings were applied late in the season on small 12 hill sub-plots in each grassplot. The effect was quite marked on the cocksfoot and ryegrass plots but could not be detected on the timothy plot.

In 1952 an attempt is to be made to control the growth of the grass largely by sheep grazing and heavier dressings of nitrogen will also be applied.

### Boron Deficiency

A sand culture experiment was commenced in 1951 to study the effect and interactions of three levels of boron and three levels of calcium on the growth and nutrition of hop plants and the resin content of the cones produced. No clear cut symptoms, which could be definitely associated with boron deficiency, were observed in the first season of growth, but under the " no boron " treatment there was a tendency for death of the growing point to occur. The experiment will be continued in 1952 on the same plants.

No cases of suspected boron deficiency have been seen or reported from the hop growing areas in the South East, but in the West Midlands cases have been reported where hops fail to grow satisfactorily and show symptoms suggestive of boron deficiency. In one such case the soil has been found to be low in " available " boron on analysis, and a pilot experiment will be carried out in 1952 to study the effect of applications of borax on the growth and nutrition of the hop plants growing on this soil.

## PLANT BREEDING

In a large scale experiment to combine *Verticillium* Wilt resistance with the English hop aroma, 3,000 seedling plants have been raised from crosses, made at Wye and East Malling, of English hops by males which are resistant to *Verticillium* Wilt. Of these 1,960 have been propagated for submission to the single plant resistance test at East Malling this year, the remainder having been discarded owing to their susceptibility to Downy Mildew.

The distribution of hop pollen in the atmosphere is being investigated. Two plants were grown in the open at Hassocks in Sussex about 10 miles from the nearest hops, these produced in the case of Brewer's Gold 6·1 seeds per 100 cones, and in the case of Fuggles 24 per 100 cones. An attempt to examine the atmosphere

of the nursery hop garden at Wye for pollen distribution by means of sticky slides failed owing to the prevalence of rain during the flowering period.

The kiln room was again used as a pressurized glasshouse for making controlled crosses and improved control of humidity and of pests was attained. Various rooting hormone treatments were unsuccessfully applied in an attempt to induce early rooting of fertile lateral branches while they are still attached to the parent bine. The breeding experiments were upset this year because electrical work had to be done on the kilns during the hop flowering period. It is hoped that a proper pressurized glasshouse will be available next season.

An illustrated report has been published describing a new variety raised by crossing the commercial variety Bramling with a male hop from Manitoba. This variety, which shows resistance to *Verticillium* Wilt, has been named " Bramling Cross " and the great interest that growers whose gardens have suffered from *Verticillium* Wilt are taking in the variety is shown by the considerable number (over 20) who have applied to the College for sets. Foundation stock has been supplied to four growers who intend to propagate the variety by layering.

The Director of the Brewing Industry Research Foundation has kindly agreed to carry out brewing trials with samples of certain of the new varieties and 14 of these have been sent for trial to the Foundation at Nutfield.

The crops from trial plots of 27 new varieties have also been distributed to firms of brewers who have kindly undertaken to brew with them and report on their brewing value.

### Genetics

Apart from the family of wild Italian hops studied by Salmon and Wormald in 1921 no information is available concerning the type and range of variation which occur in wild hops from different parts of the world. We are trying to raise families from controlled crosses made between ♂ and ♀ wild hops which are represented in the College Collection. The first of these families, pure bred *H. Lupulus Neomexicanus,* has now made one year's growth and already shows wide variations.

The Canadian wild plants obtained by Mr. Hargrave have not yet produced fertile laterals large enough to strike for use in making controlled crosses. Crosses between these wild plants were made using muslin sleeves, so that the material will not be completely

lost if they succumb to Downy Mildew as did the original introduction which produced Brewer's Gold.

The intercross of male and female wild Italian hops has been attempted with pollen stored for a year, because the female is considerably earlier flowering than the available males, but this failed to set any seed.

The families which were segregating plants susceptible to powdery mildew have been grubbed because of the danger of infecting the rest of the gardens with this disease.

Selected male hops have been sent to East Malling for testing for resistance to *Verticillium* Wilt. Two more resistant males were discovered this year.

Hairs on the upper side of the stem nodes seem to be a distinguishing character of American hops ; all the European hop varieties so far examined have hairless nodes. The character seems to be dominant and has been found in many descendants from American crosses. The detailed inheritance is not yet clear and modifying genes are evidently present since the hairiness varies from a dense down to few scattered hairs.

Four families segregating for cordifolius *v.* cut leaf have been grown for the second year. They have not given clear cut ratios and the expression of the character seems to be complicated by dwarfness which keeps the plants in their juvenile stage, in which cordate leaves are commonly produced.

### Cytology

The examination of permanent preparations made in previous years has been continued. All three of the males raised from Japanese seeds which have been examined in meiotic divisions have the chain of four chromosomes described by Japanese workers, and the chromosome relationships which result in this chain have been analysed.

Much time has been spent upon the examination of plants produced last year from buds of several varieties which had been treated with colchine, to select from the chimaerical plants pure tetraploid sections for propagation. This has involved (*a*) investigation of stoma size in normal and polyploid tissues ; (*b*) special treatment of plants for the production of actively growing root tips in which to count the chromosomes ; (*c*) chromosome counts in young leaf tissue ; (*d*) chromosome counts in seedlings from polyploid plants. Colchicine treatments have been made this year to produce polyploidy in Golding hops.

COMMERCIAL GROWTH OF NEW VARIETIES

The production of new (Wye) varieties which have been introduced commercially continues to increase from year to year. The following information as to (1) the crop marketed by Registered Producers and (2) the acreage in June, 1951, of these varieties, has been supplied by the Hops Marketing Board.

*Crop*

| | | |
|---|---|---|
| 1944 | 1,003 pockets | approx. 1,504 cwt. |
| 1945 | 1,538 ,, | ,, 2,300 ,, |
| 1946 | 1,868 ,, | ,, 2,800 ,, |
| 1947 | 2,917 ,, | ,, 4,375 ,, |
| 1948 | 3,574 ,, | ,, 5,361 ,, |
| 1949 | 3,679 ,, | ,, 5,518 ,, |
| 1950 | 5,268 ,, | ,, 7,902 ,, |
| 1951 | 5,547 ,, | ,, 8,320 ,, |

The 5,547 pockets marketed in 1951 consisted mainly of Brewer's Gold (C9*a*), 2,048 pockets ; Keyworth's Midseason (OR55), 1,059 pockets ; Bullion Hop (Q43), 823 pockets ; Early Promise (X35), 780 pockets ; Keyworth's Early (OJ47), 122 pockets ; Quality Hop (OO63), 121 pockets ; and Northern Brewer (WFB135), 108 pockets. Small amounts of the following varieties were grown : Malling Midseason (BB28), Brewer's Standby (HH44), College Cluster (N15 *bis*), Pride of Kent (170*a*), Concord (OH44), Sunshine (V94), and John Ford (WFA90).

*Acreage*

| *Variety* | *Acres* |
|---|---|
| Brewer's Gold (C9*a*) .. .. .. | 249·6 |
| Keyworth's Midseason (OR55) .. .. | 217·6 |
| Early Promise (X35) .. .. .. | 91·7 |
| Unspecified Varieties .. .. .. | 81·2 |
| Bullion (Q43) .. .. .. .. | 77·5 |
| Keyworth's Early (OJ47) .. .. | 55·2 |
| Northern Brewer (WFB135) .. .. | 12·2 |
| Pride of Kent (170*a*) .. .. .. | 11·3 |
| Brewer's Standby (HH44) .. .. | 9·6 |
| Quality Hop (OO63) .. .. .. | 8·6 |
| John Ford (WFA90) .. .. .. | 7·6 |
| Early Choice (FF21) .. .. .. | 6·0 |
| Concord (OH44) .. .. .. .. | 5·4 |
| Sunshine (V94) .. .. .. .. | 4·0 |

| | |
|---|---|
| Malling Midseason (BB28) .. .. | 2·7 |
| Bramling Cross (OT48) .. .. .. | 2·5 |
| College Cluster (N15 *bis*) .. .. .. | 2·4 |
| Brewer's Favourite (OP21) .. .. | 0·9 |
| C2 (E.M.R.S.) .. .. .. .. | 0·6 |
| WFG19 .. .. .. .. .. | 0·4 |
| OF27 .. .. .. .. .. | 0·4 |
| Odd Varieties .. .. .. .. | 0·8 |
| | 848·2 |

It is not possible to assess the yields per acre from the above figures, owing to the fact that some of the acreage consists of young, newly planted hops and also where a grower has only a very small acreage of a variety it is not always harvested separately.

At an exhibition of hops held by L'Union des planteurs de houblons d'Assche-Alost, at Assche, in December, 1951, the four Belgian-grown samples of Northern Brewer exhibited were richer in humulone than any other hops in the exhibition. Furthermore, by the organoleptic classification, two of the samples were given higher marks than any of the other varieties shown. (*Le Petit Journal du Brasseur*, 1952, 2376, 5.)

An account of the exhibition of New Varieties held in London in November, 1951, appears on page 72 of this Report.

## THE PRESERVATIVE VALUE OF HOPS

### Deterioration of Hops During Storage

Storage of samples of Brewer's Gold and Eastwell Goldings in nitrogen and hydrogen has confirmed our previous results that storage in the absence of oxygen arrests deterioration.

Samples of four varieties of hop (Brewer's Gold, Northern Brewer, Early Bird, and Eastwell Golding) are being stored under the following conditions and analysed at three-monthly intervals :

(i) In Oxygen.
(ii) In Nitrogen.
(iii) In Hydrogen Sulphide.
(iv) In Air, after treatment with Hydrogen Sulphide.

Samples are also being stored in atmospheres at various humidities and in the presence of phosphorus pentoxide ; silica gel ; zinc chloride ; calcium chloride ; and activated charcoal, to obtain

further information on the effect of moisture and of hop essential oil on the rate of deterioration.

A study of the peroxidase present in the hop cones indicates that the activity in the green hop is greater than in the dried hop. Its action on o-phenylene diamine has been studied both with respect to the products formed and the effect of pH, temperature and concentration of hydrogen peroxide on the activity.

### The Rate of Formation of Humulone

The rate of formation of humulone has been followed in the ripening cones of Northern Brewer and Brewer's Gold. The amount of humulone reached its peak at four weeks from its first appearance —one week longer than in 1950—and remained constant for two weeks, then diminished slightly. In 1950 the period of constant amount was three weeks. The total soft resin reached its maximum five weeks after the first appearance of humulone.

### Sampling Cones from Individual Plants

Further data has been obtained on the resin content of cones from different positions on the plant. Cones were taken from three positions on five plants in each of four varieties. These were dried and analysed, and although, as in 1950, the results show some variation, the data is insufficient to enable a definite conclusion to be drawn.

### Analyses of Hops

During the year 526 analyses of hop samples were carried out, these comprised :

33 New Varieties.
111 Selected Goldings.
89 Comparison of Hand and Machine picked hops.
102 (51 samples in duplicate) Exhibition of New Varieties.
75 Storage experiment samples.
20 Drying experiment samples.
36 Samples taken during ripening.
60 Samples from different positions on individual plants.

## HOP DRYING

Much difficulty has been experienced in procuring thermostats capable of controlling the air temperature in the laboratory kilns with sufficient accuracy for experimental work ; eventually a set

specially designed and made for the purpose was installed in time for use in 1951.

The kilns were tested and found to function satisfactorily.

Six series of loads were dried to compare the effects of using various amounts of sulphur and of sulphur dioxide (from the liquefied gas) upon the brewing value and keeping property of hops ; in each series a load was dried without sulphur as a control. Samples are being analysed periodically to follow the changes taking place during storage. The bulks of each of the loads of hops have been sent to the Brewing Industry Research Foundation for brewing trials.

## SURVEY OF HOP-PICKING MACHINES

A survey of hop-picking machines in use in the West Midland district was carried out ; Mr. J. A. C. Gibb, of Wye College Engineering Department, and Mr. G. P. Chater, of the N.A.A.S. West Midland Province, were in charge of the work. The survey was financed by a special grant from the A.R.C.

Two teams of four students each visited six machines on three occasions at weekly intervals, thus obtaining records from a total of twelve machines picking slightly under-ripe, ripe and slightly over-ripe hops. Samples of the machine picked hops were analysed for breakage of the cones and leaf and stem content ; further samples were taken, along with hand-picked samples for comparison, for chemical analysis. Records were made of the labour employed on the machine, for bringing hops to the machine, and also of the rate of feeding and output of the machine.

The results show considerable variation in quality of picking, depending largely upon the nature of growth of the hops being picked but also upon the way in which the machines were being used. In general the machine-picked hops were lower in soft resin content than the corresponding hand-picked hops.

A full report on the survey will be found on page 42 of this Report.

## ADVISORY WORK

Advisory work, which has been continued in co-operation with the N.A.A.S., has included the usual problems of manuring, cultivation, selection of sites for new hop gardens, design and modification of oast houses and management of drying.

Advice has also been given in connection with the experiments

on hops and management of the hop yards at Rosemaund Experimental Husbandry Farm, near Hereford.

Visits have been received from many hop growers and also from hop research workers in Australia, New Zealand, and the U.S.A.

## GENERAL

Close liaison has been maintained with the Hops Marketing Board, the Brewing Industry Research Foundation and East Malling Research Station.

Dr. R. H. Roborgh spent four months in the Department studying hops preparatory to taking charge of hop research under the D.S.I.R. of New Zealand.

## PUBLICATIONS

1. Department of Hop Research Report for 1950. May, 1951.
2. E. S. Salmon. "'Bramling Cross.' A new hop resistant to *Verticillium* Wilt." Wye College Leaflet. May, 1951.
3. A. H. Burgess. "Notes on the physics of hop drying." Wallerstein Laboratories Communications. June, 1951.

A. H. Burgess,
*Head of Department of Hop Research.*

# SOME OBSERVATIONS ON THE NUTRITION AND MANURING OF THE HOP PLANT IN THE LIGHT OF RECENT WORK AT WYE

F. C. Thompson

In this paper an attempt will be made to review present ideas on hop manuring and nutrition in the light of the experimental data collected and field observations made during the course of the past three or four years.

## Nitrogen

As a quick growing plant the hop requires heavy nitrogenous manuring. The actual amount required will depend on a number of conditions of which one of the most important is the season. The quantity recommended by Dr. Burgess (1949) at Wye, of 300 lb. per acre nitrogen for the Fuggle variety and for stronger growing varieties about 270 lb. per acre can be taken as a working guide.

It must, however, be stressed that the results of a long-term experiment by Burgess showed that the responses to different amounts of nitrogen within the range of 230 lb. to 310 lb. per acre, depended on seasonal conditions. In some seasons significant differences were obtained from the different amounts applied, but in other seasons no such differences showed up. A good illustration of the effect of season can be seen where a sharp cold spell occurs in the early stages of growth (e.g. in 1950). The resultant check in nitrification in the soil can result in the hops showing nitrogen deficiency — the foliage turning a pale yellow-green, the leaf petioles turning a bright red and growth being checked. With the onset of warmer weather the hops grow away and the foliage turns a normal green colour, the nitrogen deficiency symptoms disappearing without any further application of nitrogenous fertilizer.

In view of these seasonal effects it is considered that the main emphasis in relation to nitrogenous manuring should be placed on applications as quick acting top dressings throughout the growing season, and that these should go on preferably in three applications as advised by Burgess, spaced out evenly so as to

cover the period of most rapid growth between the beginning of April and the end of June.

A basic reserve of more slowly available nitrogen is desirable, and at the present time this is usually supplied by winter dressings of dung or shoddy. Many growers also give spring applications of such manures as meat-and-bone meal. The main importance of such so-called organic manures, however, should be to supply humus to the soil and help in maintaining soil structure, but the quantities which it is economic to apply at present prices are unlikely to have any appreciable effect on soil structure, except in the case of dung. The nitrogen content of dung is such that an average dressing of, say, 15 ton per acre should supply a considerable amount of nitrogen. The availability of the nitrogen in dung is a debatable question, however, and current views are that it should not be assessed as being very high ; where dung is used regularly, however, the residues remaining from an application in any one year may provide a source of nitrogen available to the plant in subsequent years.

### Phosphate

The evidence to date on the demand for phosphate by the hop suggests that where a young plant is being established on a soil initially low in available phosphate a good response will be obtained to relatively heavy dressings of phosphatic fertilizers. With an established plant, however, even on soils where the available phosphate is low, hops can grow satisfactorily with much reduced dressings of phosphate provided the root range is good—in fact on certain experimental plots hops have been growing well for some years without any application of phosphate.

Experimental evidence is not yet available to enable precise recommendations as to the quantity of phosphate to be given to established hops, but a strong case can be made for hops on soils shown by analysis to be " very high " in available phosphate to receive reduced applications of phosphate and in any case not to exceed the 230 lb./acre of phosphoric acid ($P_2O_5$) recommended by Burgess. Analytical studies of the plant indicate that the demand for phosphate is at the beginning of the growing season and there is no evidence to show that later applications will benefit the crop.

A further observation from analytical studies is that high phosphatic manuring with the fertilizers commonly used in commercial practice and in which the phosphate is present as a calcium compound, can sometimes lead to a significant increase in the

calcium in the plant. This in turn may lead to a suppression of potash uptake owing to antagonism between calcium and potassium.

### Potash

From general observations both in the course of advisory work and from experimental evidence, it is becoming clear that potash deficiency in hops is more widespread than had been previously realized. In some cases the deficiency is relatively straightforward, occurring on soils initially low in available potash which have been in hops for only a short time, and it is evident that the soil potash has not been built up to the level needed for hops. In other cases, the deficiency may arise in established gardens where potash manuring over a number of years has been quite heavy, and here potash fixation, low potash in the subsoil and restricted root range of the plant may one or all be associated factors. The first two factors are, in fact, closely related in that potash fixation takes place in the top few inches of soil and so prevents a build-up of potash in the subsoil. With regard to the root range of the plant the important factor is the soil profile; a soil of good texture, depth and drainage will enable the plant to develop a large root system and so make full use of even small amounts of available potash present in the soil. A shallow soil over an impervious subsoil, be it clay or sandrock; one with an iron or cultivation pan near the surface; or a soil which tends to be waterlogged for long periods during the winter and so kills off the roots submerged in the water, will all tend to favour potash deficiency by limiting the root range. Since the main feeding roots of the hop develop in the top few inches of soil it might be thought that restriction of the formation of a deep rooting system would have very little effect on the nutrition of the plant, but it must be remembered that hops are continually being cultivated throughout the growing season and surface roots in this way damaged and destroyed. On good deep soils this may not be of great importance as the large deep root system developed can draw on subsoil nutrients in sufficient amounts. On soils of restricted root range, however, the surface soil is of major importance and some method of encouraging good root development in this zone must be sought. In this connection the use of grass cover crops and possibly straw mulching might be beneficial. The growth of hops under grass is being investigated by the Department, primarily from the aspect of building up organic matter and soil structure; as a secondary factor, however, this method may benefit potash

uptake by the plant by making the soil potash more available and encouraging surface rooting.

There is no doubt that where soil conditions restrict nutrient uptake by the hop plant, the first deficiency to show up is potash. The precise physiological reason for this is not known but it may be related to the high calcium content of the hop which demands a high potassium content to maintain a satisfactory ionic balance in the plant.

### Acidity

It has generally been considered that the hop grows best on a soil of pH around 6·5 to 7·0, but the evidence gained in the course of both advisory and experimental work has thrown some doubt on this. There is no doubt that under certain soil conditions hops can grow very well at a pH of 5·5—i.e. moderately acid conditions. This factor may be of importance in that under such acid conditions the calcium uptake by the plant is reduced and so the demand for potash is not so great.

### Magnesium

In hop manuring, as with other crops, the major requirements are for nitrogen, phosphate and potash together with liming where necessary to bring the soil to a suitable pH.

Of other nutrient requirements that for magnesium appears to be the most important from present knowledge. Magnesium deficiency in the hop shows up by the development of a characteristic chlorosis (yellowing) of the leaves between the veins, with the subsequent development of an interveinal scorch. In bad cases the deficiency results in severe defoliation of the leaves and can result in a marked drop in yield of hops but such cases are not common. Deficiency symptoms can frequently be found, particularly under seasonal conditions which restrict nitrogen uptake since this is closely related to magnesium uptake, but from the evidence available it does not appear that the presence of leaf symptoms without severe defoliation results in any appreciable loss in yield.

One reason for the latter may be the fact that the effect of deficiency develops late in the season when the plants have had a chance to make good growth, and that it is only where the trouble is sufficiently severe to cause marked defoliation, resulting in the hops not growing out properly, that the yield is seriously affected.

The deficiency can arise on the lighter sandy soils under acid conditions, where the magnesium is leached out and brought

down below the level necessary for the hop under normal NPK manuring. It can also arise in old-established gardens which have been heavily manured for many years and where the level of available potash has become extremely high, although the magnesium level may be adequate for more normal conditions. Such potash induced magnesium deficiency can arise on alkaline soils and frequently the leaf symptoms developed differ from those found on acid soils, showing more chlorosis (yellowing) and less scorch; this difference in symptom expression, however, can also be associated with the level of available nitrogen in the soil. Magnesium deficiency can, in fact, also show up transiently where the plants are nitrogen starved but in this case a spell of favourable weather or a top dressing of nitrogenous fertilizer can result in the rapid disappearance of symptoms.

In authentic cases of magnesium deficiency, it has been found that the trouble can be controlled by soil applications of agricultural Epsom Salts at around 5 cwt./acre. Where the trouble is associated with very high levels of potash, complete omission of potash manuring for a year or more in conjunction with applications of Epsom Salts speeds up recovery.

### Minor Elements

Hops have been grown in sand culture with complete omission of manganese and zinc but so far the effect produced is simply a stunting of growth without any other characteristic symptoms. Under field conditions no symptoms have been seen as yet which could be associated with deficiencies of either of these elements.

Iron deficiency has been produced in sand culture but the characteristic symptoms of chlorosis only appeared transiently, the plant recovering its normal green colour as fresh foliage developed; growth, however, remained stunted. True iron deficiency has not been seen in the field, though hops can be found growing on chalk. On very acid soil, induced iron deficiency has been observed, caused by an excessive uptake of manganese with consequent suppression of iron uptake.

The boron nutrition of the hop is being studied in sand culture at Wye. Deficiency of boron leads to death of the growing points of the shoots. No symptoms characteristic of the deficiency have been observed in the field in the South-East and this may be due to the relatively recent geological origin of the soils in this part of the country. In the West Midlands, however, where the geological formations are much older, and consequently the natural reserve

of boron is lower, the possibility of the deficiency occurring is more likely, and one case under investigation where hops are failing, may be due to this deficiency. Boron deficiency has been reported in hops in New Zealand (Askew and Monk, 1951) where the trouble has been overcome by soil applications of borax.

References

Askew, H. O. and Monk, R. J. 1951. " Boron in the nutrition of the hop." Nature, **167**, 1074.

Burgess, A. H. 1949. " The nutrition of the hop crop." *Farming*, **3**, 235-9.

# THE EFFECT OF SOIL ACIDITY ON THE GROWTH OF HOPS. I

F. C. Thompson, E. G. Cripps and G. A. Watson

Reference has been made in a previous report (Thompson, *et al.*, 1950) to some observations on manganese toxicity in hop plants. As a result of these observations, and since there was some suggestion that the leaf symptoms shown might in part be associated with magnesium deficiency as well as manganese toxicity, it was decided to lay down a small trial in the garden where the disorder was found.

## Experimental Procedure

The experimental area was located on a light (very fine sandy loam) sedentary soil of the Pembury Series, derived from the Tunbridge Wells Sand. The experiment was started in 1949 and continued in 1950 and 1951.

The design of the experiment was a simple randomization, four treatments being replicated three times within the experimental area. Each plot consisted of four plants surrounded by a single row of guard plants. The hops—variety Fuggle—were fully established and grown on a 6½ ft. " Square plant ".

The treatments applied were :

| | |
|---|---|
| Calcium .. .. .. | as calcium sulphate in the form of gypsum at 1 ton per acre. |
| Lime .. .. .. | to lime requirement, using hydrated lime. |
| Magnesium .. .. | as magnesium sulphate in the form of Epsom Salts at 10 cwt. per acre. |
| Lime plus magnesium .. | lime to lime requirement plus 10 cwt. per acre Epsom Salts. |

The first dressing of lime (to the requirement of the 6-12 in. layer of soil) was applied to the limed plots on January 14th, 1949, and subsequently ploughed down. The second dressing of lime (to the requirement of the 0-6 in. layer of soil) was applied on February 10th, 1949, and worked into the surface soil. No further

liming was carried out during the three year period of the experiment.

Epsom Salts and gypsum were applied at the rates given in the Spring (March-April) of each year 1949-51.

The whole experimental area received a standard NPK dressing each year, at the rate of 300 lb. per acre N, 200 lb. per acre $P_2O_5$ and 200 lb. per acre $K_2O$. The phosphate and potash were applied as superphosphate (18 per cent. $P_2O_5$) and muriate of potash (60 per cent. $K_2O$) in the spring (March-April) and the nitrogen as sulphate of ammonia in two dressings, the first in April and the second in June.

Observations were carried out during the growing season in each year and leaf samples taken either at the end of June or the beginning of July taking a bulked sample of 12 first fully formed leaves from each plot. Soil samples were also taken from each plot during December in each year.

The leaf samples were dried and ground and then analysed by the standard methods developed in the department. Determinations were made of N, P, K, Ca, Mg, Fe and Mn.

The soil samples were analysed by quick-test techniques for available potash, available phosphate and available magnesium. pH measurements were also carried out, using the glass electrode.

## Experimental Results

### Field Observations

The plots were visited on a number of occasions during the growing season in each year, but on no occasion could any obvious differences between treatments be detected. Seasonal conditions varied during the period of the experiment, being very dry in 1949 and very wet in 1950, while 1951 fell somewhat between the two. Nevertheless, growth in each year was generally good on all plots and only at the end of 1949, the dry year, did slight symptoms of chlorosis and scorch appear on the leaves; these symptoms were probably due to premature senescence brought on by the dry season.

In 1949 a young replant was observed in one guard row, showing a marked chlorosis with necrotic speckling. These symptoms were similar to those showing in young plants in this garden in 1948 and found to be associated with manganese toxicity and induced iron deficiency. Iron injections were made on the chlorotic leaves of this plant in 1949, and a definite response to the injections was obtained. In 1950, however, when the plant had

become fully established, no symptoms of chlorosis or necrosis appeared, and it would seem from observations in other gardens that it is usually only young plants which are affected under these conditions.

### Leaf and Soil Analyses

As stated above, determinations were made of N, P, K, Ca, Mg, Fe and Mn on leaf samples, and pH, available K, available P and available Mg on soil samples. In the leaves, however, only the contents of Ca, Mg and Mn show significant treatment effects, so only these results are given in Table 1. Similarly in the case of the soil only the pH and available magnesium show significant effects due to treatment and these results are given in Table 2.

Table 1

Chemical Composition of Leaves taken from Experimental Plots. Mean Values for Replicates of Three Plots.

| Treatment | Calcium % dry matter | | | Magnesium % dry matter | | | Manganese p.p.m. in dry matter | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1949 | 1950 | 1951 | 1949 | 1950 | 1951 | 1949 | 1950 | 1951 |
| Calcium Sulphate .. | 0·97 | 1·32 | 0·95 | 0·34 | 0·27 | 0·26 | 335 | 492 | 195 |
| Lime .. | 1·11 | 1·23 | 1·06 | 0·31 | 0·23 | 0·24 | 193 | 168 | 125 |
| Magnesium Sulphate .. | 0·95 | 1·09 | 0·86 | 0·38 | 0·30 | 0·30 | 296 | 366 | 253 |
| Lime plus Magnesium | 1·04 | 1·21 | 1·27 | 0·31 | 0·29 | 0·33 | 257 | 185 | 153 |

Statistical examination of the results for leaf analysis shows that in each year liming has significantly increased leaf calcium and applied magnesium has significantly increased leaf magnesium (except in the presence of lime in 1949), but in neither case is the effect large. Liming has also significantly reduced leaf manganese, an effect which in this case is quite large. Although the samples were taken at approximately the same date in each year, the results show variations between seasons, but these are not consistent.

When the results are considered in relation to data obtained from other experiments where mineral deficiencies have been developed, it is evident that the hops on the " no calcium " and " no magnesium " plots in this experiment, have been able to build

up levels of calcium and magnesium which are just above the critical values presumably owing to the large root range enabling the plant to make full use of small amounts in the soil and, in the case of calcium, an appreciable additional amount of this element has been applied in the superphosphate. The leaf manganese contents on the "no lime" plots, however, are at levels where manganese toxicity would be expected to develop.

Table 2

Analysis of Soils from Experimental Plots. Mean Values for Replicates of Three Plots.

| Treatment | pH | | | | | | Available magnesium p.p.m. in Soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-6 in. depth | | | 6-12 in. depth | | | 0-6 in. depth | | | 6-12 in. depth | | |
| | 1949 | 1950 | 1951 | 1949 | 1950 | 1951 | 1949 | 1950 | 1951 | 1949 | 1950 | 1951 |
| Calcium Sulphate .. | 4·9 | 4·8 | 4·6 | 4·7 | 4·6 | 4·5 | 68 | 33 | 44 | 70 | 50 | 38 |
| Lime .. | 7·0 | 6·5 | 6·1 | 5·6 | 4·9 | 4·8 | 51 | 23 | 31 | 50 | 28 | 30 |
| Magnesium Sulphate .. | 4·8 | 4·9 | 4·7 | 4·4 | 4·6 | 4·6 | 65 | 69 | 77 | 90 | 98 | 80 |
| Lime plus Magnesium Sulphate .. | 7·0 | 6·5 | 6·6 | 5·5 | 5·0 | 4·9 | 52 | 55 | 63 | 46 | 44 | 42 |

Stastical examination of the results of soil analysis shows that in the first year of the experiment liming has significantly raised the pH in both the surface soil and the subsoil. In the second and third years, when no additional lime was applied, this effect has been maintained in the surface soil though the pH has dropped as would be expected; in the subsoil the effect of liming has practically disappeared at the end of the three year period. Applied magnesium has slightly increased the available magnesium in the surface soil over the three year period, while on the "no magnesium" plots the available magnesium has decreased over the three year period, both in the surface soil and the subsoil.

It is evident from the results of leaf and soil analyses that applied treatments have influenced the nutrition of the hop plants studied in this experiment, but the treatment effects have not been reflected in the growth made by the plants or resulted in the appearance of symptoms of mineral deficiencies or toxicities associated with acidity. These results are surprising and contrary to the conclusions drawn from some earlier observations in the

field and from an experiment reported by Burgess (1950). It must be pointed out, however, that during the past two years other evidence has been obtained which suggests that under certain soil conditions hops may tolerate an appreciable degree of acidity and still grow well. The problem is now being investigated in detail in soil culture experiments at Wye, in which hops are being grown in three soil types, at four pH levels and two nutritional levels.

Summary

1. A randomized experiment is described which was laid down on a light, acid soil, to study the effect of soil acidity on the growth of hops of the Fuggle variety.

2. The treatments applied were calcium as calcium sulphate (gypsum); magnesium as magnesium sulphate (Epsom Salts); lime; lime plus magnesium as sulphate (Epsom Salts).

3. The results of field observations, leaf analyses and soil analyses over a three year period are discussed. Applied treatments had statistically significant effects on the soil and on nutrient uptake by the plants, but were not reflected in the growth made by the plants or by the development of mineral deficiencies or toxicities.

4. The conclusion is drawn that under certain soil conditions hops can make good growth at much lower pH levels than had previously been thought to be the case.

References

Burgess, A. H. 1950. "Hop manuring and cultivation experiments." *Rept. Dept. of Hop Research, Wye College for 1949*, 18.

Thompson, F. C., Cripps, E. G., and Burgess, A. H. 1950. "The effect of acidity on the growth of hops." *Rept. Dept. of Hop Research, Wye College for 1949*, 43.

# VARIATION IN MINERAL CONTENT OF THE HOP LEAF

G. A. Watson

In studies of the nutritional status of plants using the mineral content of the leaf as an index, the problem of localized differences in the plant and of variations within and between seasons becomes important. The experiment described below has been carried out to study these variations in the hop plant.

## METHOD

### Field Experiment

The experiment was carried out in the years 1950 and 1951, using Eastwell Golding and Early Bird varieties in Silks Hop Garden at Wye College. Little difference was found between the two varieties and only the results for Eastwell Golding are given. The soil of this garden is a Brice Series brickearth over chalk and was ploughed out from permanent pasture in 1948. Analysis by quick-test techniques of the soil of the experimental area in January, 1952, gave results shown in Table 1, typical of a hop soil of high fertility.

In 1950, a block of 104 hills, comprising eight rows of 13 hills was taken as the test area. Four replicate samples were taken on five occasions over a period of ten weeks, each sample being taken at random from two rows of hills. Unfortunately, owing to an extreme amount of rank bine sampling could not be carried out right up to picking time as the standard leaves initially chosen could not be correctly sampled.

Table 1

Results of Analysis of Soil by U.E.S. Methods.

| Sample Depth | Soil Texture | pH | Phosphate | | Potash | | Avail. Magnesium | |
|---|---|---|---|---|---|---|---|---|
| | | | p.p.m. | Grade | p.p.m. | Grade | p.p.m. | Grade |
| 0–6″ | Silt loam | 7·7 | 8·0 | Very High | 51 | High | 50 | Medium |
| 6–12″ | ,, | 7·7 | 7·7 | High | 28 | Medium | 50 | Medium |

The same section of hops was used in 1951, but the sample area was halved, a similar sampling technique to that of 1950 being used. Sampling of some of the leaves was carried out to within a few days of picking, but the " Top Leaf " was taken only for as long as the true, vigorously growing top leaf, as described below, was available.

To determine the variation in mineral content of leaves at various points along the bine, the following standard leaves were sampled :

*Leaf " A " or " Top Leaf " :* the first pair of open young leaves below the growing point.

*Leaf " B " or " First Fully-Formed Leaf " :* the last fully-formed leaf, moving up the bine, retaining some " bloom " on its surface, all lower leaves being of harsher texture and slightly darker in colour ; generally 3-6 nodes below the " Top Leaf ".

*Leaf " C " or " Fixed-Height Leaf " :* the leaf at the height of the tie-in string, 4½ ft. from the ground.

It will be seen that during the growing period of the plant, samples of leaves A and B respectively taken at different times will all be of similar maturity, but that Leaf C samples will be of increasing maturity. As the plant matures and ceases growth, leaves A and B will mature and this difference will decrease.

In both years leaf samples were collected at approximately fortnightly intervals on fine sunny mornings. The petioles were removed and the laminae dried as soon as possible at 105° C.

The dried leaf material was ground and analysed by the Hop Department's routine methods for N, Ca, Mg, K, P, and Mn.

## Experimental Results

Heavy Bordeaux Mixture spray residues were a source of trouble in both years ; in 1950 the fifth sample of leaf A and the last three samples of leaves B and C were affected, as were the last three samples of leaf B and the last four of leaf C in 1951. Ca results were badly affected by these residues ; in 1950 the Mg results were also affected, but a refined technique of analysis eliminated the trouble in 1951. The extent of this interference is indicated in the sections below.

Results were calculated as percentages of the elements on oven dry basis and are presented as graphs of percentage element against time of sampling in Figs. 1-7.

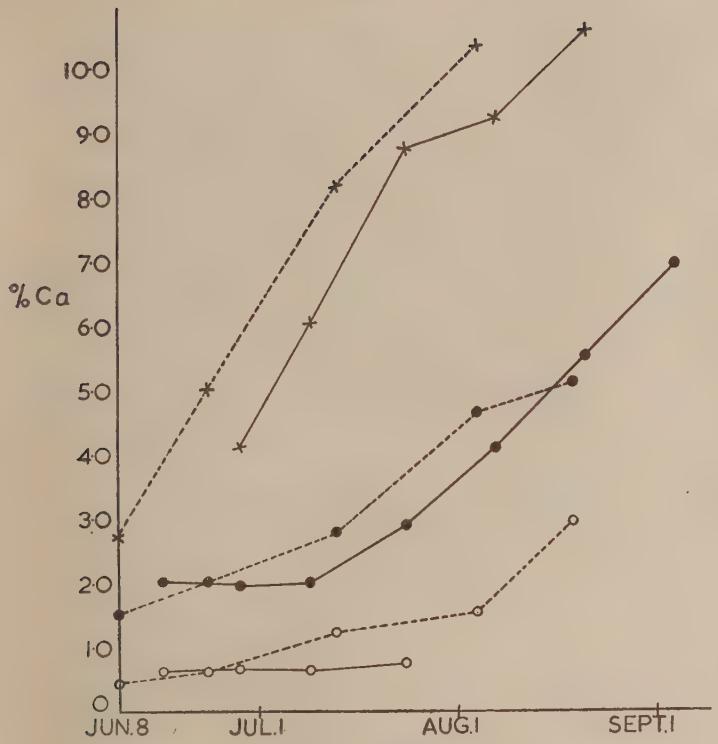


Fig. 1. Calcium

Key to Graphs

Leaf "A" or "Top Leaf". 1950.
Leaf "A" or "Top Leaf". 1951.
Leaf "B" or "First Fully-Formed Leaf". 1950.
Leaf "B" or "First Fully-Formed Leaf". 1951.
Leaf "C" or "Fixed-Height Leaf". 1950.
Leaf "C" or "Fixed-Height Leaf". 1951.

Statistical analysis of the data for height and time of sampling gave the following results :

Calcium.

*Occasion.*

Leaf A. The Ca content remains steady at a low level until late in the season when the onset of maturity causes it to rise.

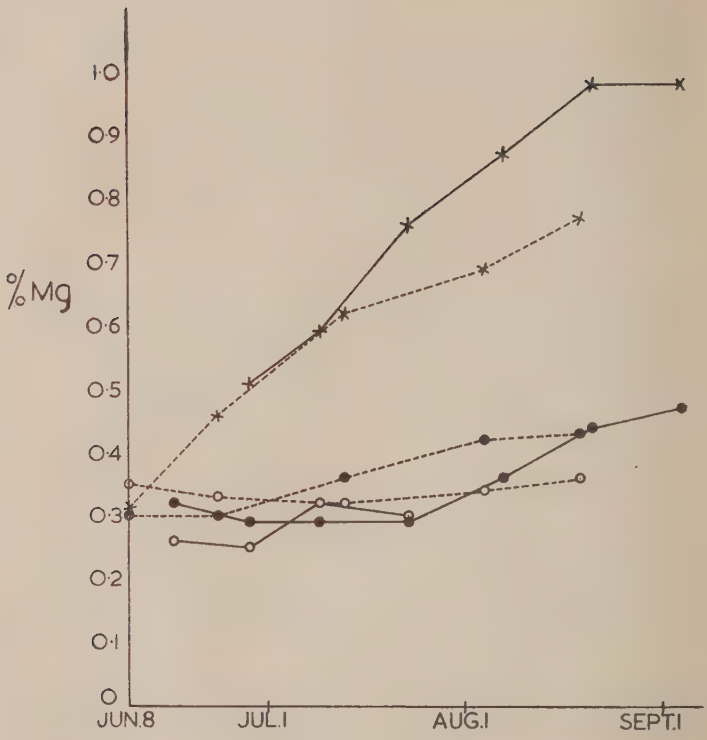


Fig. 2. Magnesium

Leaf B. Values remain fairly steady until early in July after which rapid significant increases occur between samplings up to the end of the season.

Leaf C. Sharp significant increases are recorded right through the season.

*Height.*

Significant differences exist between Ca content at all heights throughout the season, the order being C > B > A.

From Fig. 1 it is seen that the tendencies for Ca accumulation are very similar for both years. Spray residue interferences must have affected the absolute values of the Ca but the tendencies are clear cut and are confirmed on reference to other experimental work.

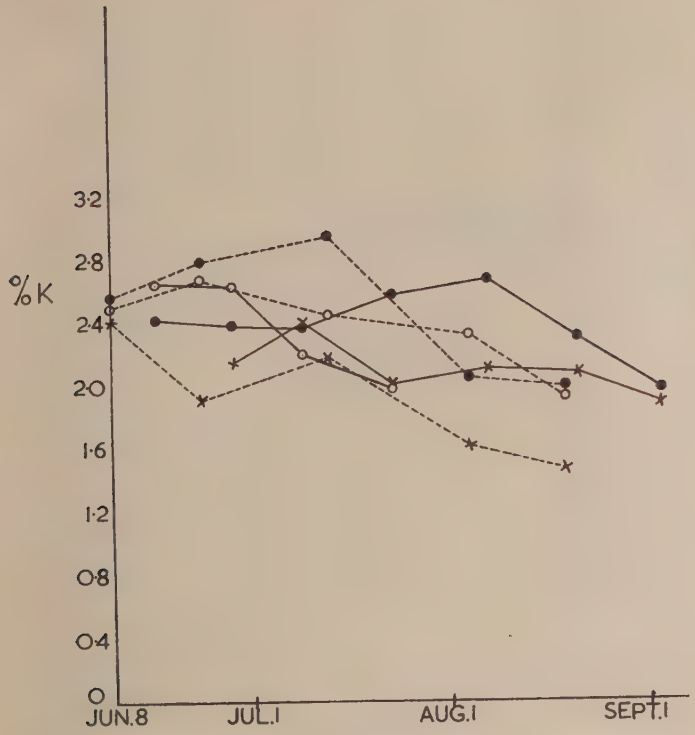


FIG. 3. Potassium

MAGNESIUM.

*Occasion.*

Leaf A. No significant variation occurs through the season.

Leaf B. After being initially at a similar level to that in Leaf A, the Mg content significantly increases, in 1950 at the beginning of July and in 1951 in late July, but becomes steady towards the end of the season.

Leaf C. The Mg content rises sharply and significantly until mid-August. The 1951 values for Mg from early July onwards were appreciably higher than those of 1950; this was probably due to a depressing effect in 1950 of the Bordeaux spray residue on the Mg determination

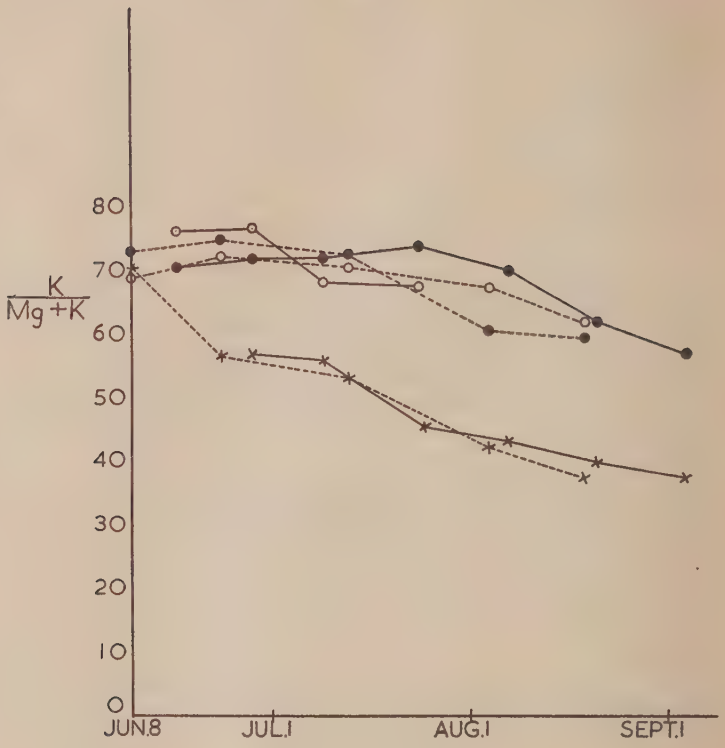


Fig. 4. K/Mg+K

—a refined technique of analysis in 1951 eliminated the interference and gave the true figures. Such interference is also possible in leaf B, although spray residues were not so heavy on this leaf.

*Height.*

All leaves are initially at similar levels of Mg content but by mid-June leaf C exhibits a significantly and increasingly greater content than the other two leaves. Leaf B begins to rise significantly in Mg content during mid-season.

Potassium.

*Occasion.*

Leaf A. An initially high level of K decreases by approximately

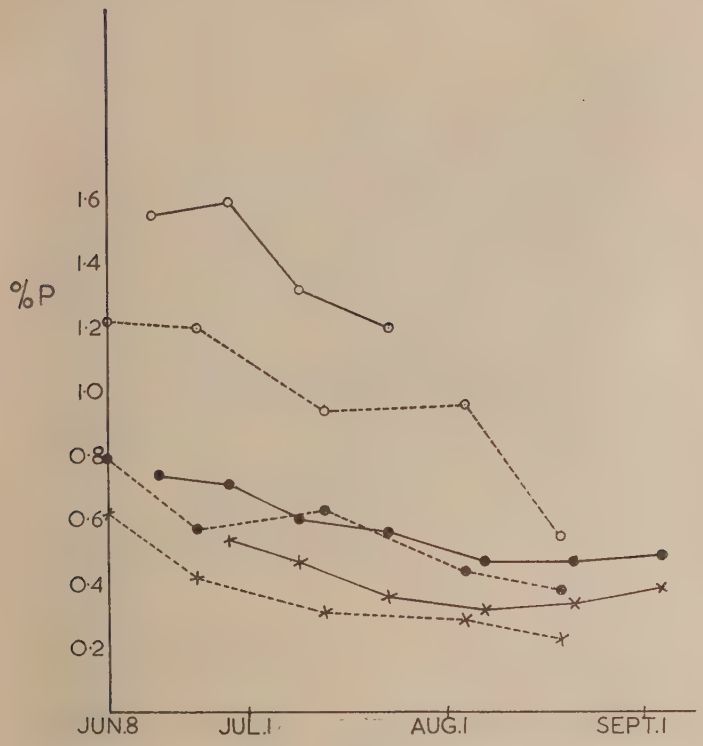


FIG. 5. Phosphorus

25 per cent. over the sampling dates, this fall being appreciably sharper in 1951 than in 1950.

Leaf B. This leaf exhibits the highest K content of the leaves in both seasons, a peak being reached at mid-July and early August in 1950 and 1951 respectively; following the peak significant decreases are recorded in both years.

Leaf C. Over the season a significant decrease is noted, this being much more pronounced in 1950 than in 1951.

*Height.*

In all leaves the K content is lower at the end of the season than at the beginning; the peak shown by leaf B is followed to a smaller extent in leaf C at a lower level of K content,

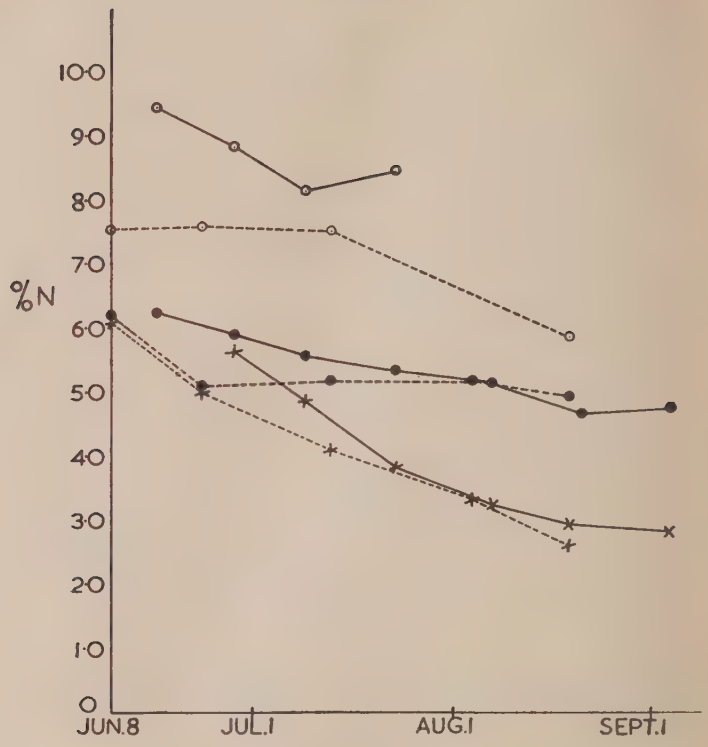


Fig. 6. Nitrogen

leaf A occupying a mid-position. In 1951 leaves B and C were not significantly different at the end of the season although this was not so in 1950, leaf C then being significantly lower in K content than leaf B.

$$\frac{K}{Mg. + K}$$

*Occasion.*

Leaf A. A tendency exists through the season for the ratio to decrease, this decrease being significant over the sampling extremes.

Leaf B. The ratio is fairly steady until late July, when the increasing Mg and decreasing K contents become

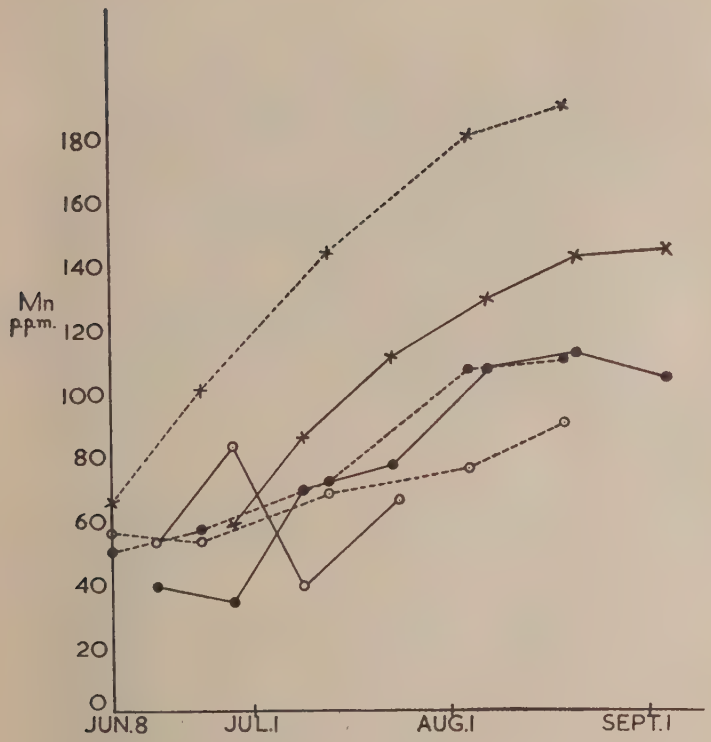


FIG. 7. Manganese

apparent, after which it significantly decreases to the end of the season.

Leaf C. Values fall sharply and significantly through July but the decrease is non-significant during August-September.

*Height.*

Significant differences occur between leaves A and B in 1950 on the fourth sampling date and in 1951 on the first, second and fourth dates, as indicated in Fig. 4. Leaf C ratio is significantly lower than that of leaves A and B in both seasons, the great difference being predominantly due to the very high values for Mg in that leaf.

PHOSPHORUS.

*Occasion.*

Leaf A. Little difference exists between the first two samplings but thereafter the P content decreases sharply to the end of the season.

Leaf B. A significant decrease over the season occurs.

Leaf C. The P content decreases significantly until late July when a minimum is reached; a slight significant rise from this value was noted in 1951.

*Height.*

At all sampling dates the P content varies significantly, values being in the order A>B>C, with all leaves approaching the same level by September. Leaf A contains considerably more P in 1951 than in 1950 and this difference is seen to a lesser extent in leaves B and C also.

NITROGEN.

*Occasion.*

Leaf A. In 1950 the N content remains steady at a high level until early July after which a significant decrease occurs; in 1951 significant decreases occur during June although levels remain appreciably above those of 1950, the N content, however, showing no significant change over the last two samplings.

Leaf B. After a significant decrease over the first two samplings the N content remains steady during 1950, but in 1951 a non-significant fall is shown at each sampling date with a significant decrease occurring over the whole season.

Leaf C. Comparatively sharp significant decreases between samplings are shown in both seasons up till the end of July after which the fall becomes non-significant.

*Height.*

Leaf A exhibits considerably higher levels of N than the other two leaves with B and C following in that order. All differences between samples from different heights shown in Fig. 6 apart from that between the first two samplings of leaves B and C in 1950 are significant. Initial levels of N are appreciably higher in all leaves in 1951 than in 1950 but by late July leaves B and C for both years become practically equal in N content.

MANGANESE.

*Occasion.*

Leaf A. Rather wide fluctuations in Mn content are shown in 1951 with no significant overall tendency but in 1950 a significant increase over the whole season is shown.

Leaf B. Initially low values are recorded steadily rising with a significant increase during July, the contents showing little change during August.

Leaf C. Significant increases are recorded right through the season up to early August after which the increase is non-significant.

*Height.*

No significant difference exists between the three leaf Mn contents at the beginning of the season but through the sampling period leaf C content becomes significantly greater than that of either of the other two leaves with B and A following in that order. The Mn content of leaf C in 1951 is considerably lower than that of 1950 although the other two leaves did not show this difference.

## DISCUSSION

The mineral elements examined can be divided into two groups : those which accumulate in the leaf during the growing season—Ca, Mg and Mn—and those of which the percentage content decreases—N, P and K.

Now, remembering that leaf C is of increasing maturity throughout the sampling period whilst leaves A and B are only so after the vigorously growing period has ended, the graphs shown in Figs. 1, 2 and 7 indicate that the levels of Ca, Mg, and Mn in the hop leaf are direct functions of the maturity of the particular leaf sampled.

The abnormally high level of Ca obtaining in the hop plant may be a reflection of the intense metabolic activity required to develop the large vegetative bulk of the plant during its short growing season. Taken up in large amounts from the soil the Ca will act as a carrier for acidic groups moving through the plant to be deposited as an excretory product as the organic complexes are built up.

The second group of elements present an entirely different picture : in the young, vigorously expanding " Top Leaves " high

levels of N and P are only to be expected, and significant differences still existing at a lower level between leaves B and C are an indication of their respective metabolic activities. The importance of easily available sources of N and P during growth flushes, with a plant which may easily grow 6 in. or more in length daily with leaf pairs containing 10·0 per cent. N and 1·50 per cent. P, can easily be seen.

An interesting point of comparison between the seasons 1950 and 1951 is in the appreciably higher levels of N and P occurring in 1951, particularly in leaf A.

K does not decrease as sharply through the season as N and P, nor is there such a large difference between the leaves. The main points of interest are that leaf B shows the highest K content of all leaves and in both seasons a peak is reached at mid-season in this leaf; it would be interesting to find out whether this peak can be influenced by early summer applications of N and/or K, and if it has any effect on the crop.

The practical application of this work is to offer guidance on the correct sampling procedure for advisory work. To distinguish the leaves most sensitive to nutritional disorders would require an elaboration of this experiment using optimum, unbalanced, and deficient conditions of growth; leaf A would probably be most sensitive to N and P deficiency, leaf B to K deficiency and leaf C the best indicator of Mg deficiency and of Mn toxicity. However, the leaf normally, and most conveniently, sampled is the "Fixed Height Leaf". With young plants, of course, this will correspond closely to leaf B but as the season progresses leaves of increasing maturity will be sampled. Thus over the season samples of greatly varying mineral content will be dealt with and a direct comparison of samples taken in August cannot be made with ones taken in early June. For instance a leaf C sample taken in early June with a K content of 1·80 per cent. and a Mg content of 0·40 per cent. would indicate K deficiency, whereas a sample taken in August, giving the same analytical figures, would indicate severe Mg deficiency.

K and Mg interact to a large extent in plant nutrition and a convenient way of assessing their balance is to use the ratio

$$K/Mg + K;$$

an unbalanced ratio will indicate the particular deficiency and low values for the nutrients at optimum balance would show general deficiency. The movement of this ratio through the season is indicated in Fig. 4.

Seasonal variation also plays a large part in the assessment of Mn toxicity occurring on highly acid soils ; samples taken early in the season showing a content of 500 p.p.m. should cause concern whilst the same figures late in season would not be abnormal.

The eventual aim of the work outlined above is to enable a plant's nutritional condition to be assessed by simple chemical analysis of the leaf alone. Until we can define optimum, unbalanced and deficient levels of mineral content in the hop leaf, two leaf samples should be taken for assessing a plant's nutritional status in the field, one from the plants to be studied and one consisting of similar leaves from plants of the same variety growing satisfactorily on similar soil in the neighbourhood. Leaf analysis must, at present, still be combined with visual diagnosis of leaf symptoms and with soil analysis to give us the full picture.

The analytical results obtained in the above experiment can be taken as satisfactory levels for a vigorously growing Eastwell Golding hop ; the extent to which these results can be applied to other varieties is a matter for further study.

## SUMMARY

Data are given showing the distribution of mineral contents in leaves of different ages on the hop plant and recommendations are made on sampling procedures.

# A SURVEY OF HOP-PICKING MACHINES, 1951

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## Introduction

Hop-picking has always been a time of great worry and stress to the grower. The employment of large numbers of people, mainly migrant, to make sure that the valuable crop is gathered in its best possible condition, has called for special measures of varying character such as the provision of temporary accommodation, supplies of foodstuffs, bedding materials, firing, water, etc., which are costly and need forethought and care in management. The South Eastern Province has drawn much of its hop-picking labour force from the many towns and villages adjacent to the hop growing areas in Kent, Surrey and Sussex ; the largest number by far having been drawn from London itself, mainly the East End. The West Midland Province has less adjacent labour and has imported from two main areas, namely, South Wales and the " Black Country ".

In the South East little difficulty is, as yet, experienced by growers in obtaining sufficient labour to pick their crop in about three weeks, but in the West Midlands the labour supply has been decreasing for a period of perhaps 12-14 years. This decrease in the West Midlands is the result of several causes, and the picking period has for years averaged four to five weeks rather than three weeks. Firstly, the younger people have not followed the tradition of their parents in spending a time of holiday in the hop yards. They have cycles, buses, etc., which enable them to see much more of the country and this lessens the attraction of hop picking. Secondly, the parents are now forced, by threat of prosecution, to send their children to school at the ordained time, which usually means that they cannot, in the West Midlands, remain till hop-picking is finished. Thirdly, the average hop-picker now earns more money at his usual occupation than heretofore, and in most cases receives pay during his holiday, with the result that the urge to earn extra money by picking hops is far less insistent.

For some years the West Midlands growers have been competing for an ever-decreasing supply of migrant labour. Picking costs

have gradually increased, but it is obvious that, in spite of incentives of all kinds, the labour supply has continued to decrease, thus making it physically impossible for all growers to pick their hops in their best condition. It is not surprising, therefore, that a great deal of interest was taken in hop-picking machines and that most of the pioneering work was done in the West Midlands. This interest continues to grow and is now beginning to spread slowly to the South Eastern Province.

## PICKING MACHINES

Records of early machines for picking hops can be traced back for about one hundred years, but in this country little serious or successful work was done until Messrs. McConnel and Hinds brought out a machine in 1934 which, with modifications, has been in continuous use up to the present time. A different type of machine, made by The Bruff Manufacturing Company, was produced for commercial operation in 1948.

The number of machines now in use is as follows :

| *Type* | | *West Midlands* | *South East* |
|---|---|---|---|
| McConnel-Hinds | Plucker Bank | 6 | 1 |
| ,, ,, | Flying Finger | 4 | 2 |
| Bruff | Large .. | 34 | |
| ,, | Medium .. | 4 | |

Hop-picking machines at the present time can be classified in two groups :

1. *Mobile*, moving between the rows in the hop garden or yard.
2. *Stationary*, housed in buildings near the kilns.

The two makes in commercial production, namely Bruff and McConnel-Hinds, are both stationary types. The Strettle and Burr Mobile Hop Picker is a prototype mobile machine, and there is also in existence an experimental stationary machine made by Messrs. Harvestex, and we understand that this firm intends to produce a mobile type in 1952.

### Operations in the Hop Garden

It is not necessary to sever the bine from its rootstock when using the Strettle and Burr prototype machine, but in all other cases the bine is cut about 4 ft. above ground level and transported to the picking machine. This operation of cutting and carting to the

machine usually involves at least two tractors and trailers and several men or women. The bines, one or more of which are growing round each string, are pulled or cut from the wirework and are loaded on to the trailers. To facilitate this operation a platform may be fitted either to the tractor or to the front end of each trailer, in which case one or more men on the platform cut down the strings and hand them to other men on the trailers for loading. At the same time other men are cutting the bines and strings from the ground. Some growers load the bines on to frames on the trailers in order to minimize tangling and facilitate unloading at the machine. Others roll each string into a coil, and others still take no special care when loading the strings on the trailers. A minority of growers use lorries, sometimes specially adapted, instead of tractors and trailers. Where trailers are used frequently two are coupled behind each tractor to increase the capacity of each team between changes of trailer.

### Operation of the Prototype Mobile Machine

No tests were carried out on this machine as it was not in commercial operation. Its method of operation is described briefly, however, as follows :

The hop bines are laid, one or more at a time, into picking beds on each side of the machine. The sides of these beds consist of endless belts carrying large numbers of wire combs, and the bottom is a rubberised conveyor which carries the picked hops to the leaf separators. Hop cones and some leaf and stem are struck or pulled off by the wire loops, and when the bine is stripped it is pulled backwards out of the picking bed by hand and thrown back on the soil, usually coiled round its rootstock. The leaf separator consists of a series of fans which are made to act on the stream of picked material, sucking away the leaves and loose petal, which have flat surfaces and are consequently more susceptible to suction than the round hop cones. The remainder of the picked material is then bagged off in pokes (green sacks) holding about 10 bushels.

### Operation of the Stationary Machines

In this category there are two types made by Messrs. McConnel-Hinds—the Type B, or Plucker Bank machine, and the Type G, or Flying Finger machine. The Bruff Company make a large machine, rated at 300 green sacks a day picking capacity (of green hops), and a medium machine rated at 200 sacks a day. The Harvestex experimental machine also comes into this category. The first four

machines mentioned differ in their picking, or plucking, mechanism, but are broadly speaking similar in their separating stages.

The Type B McConnel-Hinds will be described completely first, and then the other types will be described where they differ from this first machine.

## THE PLUCKER BANK MACHINE

This is the largest type of hop-picking machine in Great Britain, and is either a single-bank machine, or with two banks, one being a mirror-image of the other, housed together but picking and separating independently, and delivering finally to a common conveyor.

### The Hops Conveyor

The strings brought in from the hop garden are attached, inverted, to a conveyor which carries them into the machine and through the plucking mechanisms. The method of attachment is simple, involving only a single twist round V-shaped hooks on the conveyor. The weight of the string keeps the twist tight in the V and holds the bines securely. The rate of feeding the strings into the machine is variable, and 8 to 10 strings per bank per minute is the average.

### The Plucker Banks

Four successive plucker banks are normally fitted. Each bank consists of an endless chain conveyor moving vertically downwards, carrying a large number of cast iron or sheet steel combs, each of which is mounted on three coil tension springs. The serrations of the combs are just wide enough to pass over the stalks of the hop cones, and as the fingers move downwards the hops caught by them are picked gently and fall down on to a rubberised canvas conveyor running horizontally below. In addition to the spring-mounted combs, similarly serrated combs are fixed to the cross-bars of the chain conveyor carrying the combs, thus increasing the combing surface. Fans and agitators are fitted, which combine to swing the bines against the plucker finger conveyor and then move them away alternately. During the latter part of this cycle the bine is turned by a rubber-tyred roller, attached to the hook from which the string is suspended, which runs on a track. Thus when the bines are next in contact with the plucker bank a new face is presented to the plucking fingers. The speed at which the plucking

conveyors run increases from bank to bank, so that the treatment is progressively more severe.

### The Flying Fingers

The efficiency of the plucker banks varies under different conditions of variety, ripeness of hops, density of bines, weather conditions, etc., and in general between 60 per cent. and 90 per cent. of the hops are plucked from the bines by them. To deal with the remainder a more violent method of removal is required. The flying fingers mechanism is a form of flail or hammer-mill, and consists of two contra-rotating shafts, each carrying a number of discs, which in turn have pivoted on each of them two curved fingers. The strings are drawn between the rotating shafts, and centrifugal force throws the fingers outwards so that they come in contact with the bines and strike off most of the remaining hops and a certain amount of leaf and stem. The severity of treatment is adjusted by altering the speed of rotation of the flying fingers, and they can be set to strip everything from the bines, or, on the other hand, so that they pick most of the hops, but only a small amount of leaf and other extraneous matter.

### The Lateral Picker

The stream of picked material from the plucker banks and flying fingers now passes under the lateral picker. Before doing so it must pass through a chain conveyor carrying tined bars at intervals, and this lifts out from the main stream of comparatively small particles any long pieces such as lateral bines, which have been pulled off whole from the main bine. The conveyor elevates the laterals to the lateral picker, which consists largely of a roller conveyor. At intervals along its length there are groups of three rollers situated above, and in light contact with, three of the conveyor rollers. The second and third pairs of rollers in each group are driven faster than the first pair. As a bine is carried along the conveyor and passes between the pairs of rollers, which are spring-mounted to accommodate it, the first pair grip it, while the faster-rotating second and third pairs pluck the hops and leaves. All the rollers are rubber covered. Thus some hops are removed by each group, and in practice most of the hops on the laterals are removed before the bine reaches the end of the conveyor, when it is carried away to waste. The picking rollers naturally work more effectively if the laterals are fed to them longitudinally. The hops and leaf picked by the lateral picker fall between the conveyor rollers, and join the rest of the picked material travelling below.

### The Rubbish Separators

The picked material now consists of the following fractions:

| | | |
|---|---|---|
| Whole hops | Broken hops | Loose hop petal |
| Loose seed | Some leaf | Some stem or stalk |

The first stage in the separation of extraneous matter from hops is to remove loose petal and seed from the main sample. To do this the sample is dropped on to a wire-mesh conveyor, usually in two stages; the petal and seed falls through the mesh, while the whole and larger pieces of broken hop, plus leaf and stem or stalk ("strig") stay on top. The petal and seed is moved to one side on to a further conveyor, which carries it to join the hops later when the leaf and strig have been removed.

The leaf separator uses fans to suck the leaves away upwards from the hops as both travel from the second stage of the petal and seed separator on the wire-mesh conveyor. The leaves thus removed from the hops are held by suction against a second wire-mesh conveyor situated a few inches above the previous one, and travelling in the opposite direction. This second conveyor carries the leaves out of the suction zone, and a brush ensures their discharge on to a rubberised canvas conveyor, which carries them to waste.

The next stage of separation on this type of machine is at present only fitted to a small number of machines, and consists of a "cascade", where the hops and remaining rubbish—strig and a few leaves—are dropped on to a series of inclined rubberised-canvas conveyors, travelling upwards. The relatively round hops roll downwards, while leaves and most of the strig content is less inclined to roll, and is carried upwards and away to waste. The angle of the inclined conveyors is adjustable to allow for varying conditions of adhesion.

The final stage of separation is an inspection conveyor, where a number of operators—usually 8 or 12 women per bank—can pick out by hand any remaining rubbish.

The separated hop sample then passes to a bagging-off point, or else directly to the kilns.

## THE FLYING FINGER MACHINE

To minimize cost and size of machine the makers have developed the Flying Finger machine. Here the plucking device consists only of a larger version of the flying finger mechanism already described. The separating devices are similar to those on the Plucker Bank machine.

## THE BRUFF "300" MACHINE

This type of machine is normally found in single-bank form only. The bine conveyor is basically similar to that on the McConnel-Hinds machines, except that loading the bines on to the hooks, and unloading the spent bines takes place at the side of the machine, and not at the end. The strings are fed at the rate of up to 14 per minute to the plucking mechanism. This consists of two inclined contra-rotating plucking cylinders, each carrying series of spring tines. These tines are so arranged that, although the cylinders are rotating, the tines remain always horizontal, or at a small angle to the horizontal, as they are carried round. The strings are suspended between the two cylinders; so the hops are subjected to a pull from the tines on either side constant in direction and cushioned by the spring in the tines. Thus they are picked relatively gently. The cylinders are about 18 ft. long, and the bine is picked completely by the time it reaches the outlet end. The severity of treatment can be altered by increasing or decreasing the speed of rotation of the cylinders.

### The Rubbish Separators

These are basically similar to those fitted to the McConnel-Hinds machines. First, however, some petal and the seed is filtered off by a narrow-spaced roller conveyor, and is carried to the delivery end of the machine, to join the hops later. Then the laterals are lifted in the same way as was described before, and are picked by a somewhat similar lateral picker; minor differences are that only the picking rollers are covered with soft rubber, and in the method of spring-loading the picking rollers.

The leaf is sucked away from the hops and strig as the bulk of the picked material is projected from the end of the conveyor carrying them from the picking cylinders. The air-stream carries leaf and petal to a perforated drum, through which the fan is sucking, and while the leaves, except for very small pieces, remain outside the drum and are carried round and out of the suction area to be discharged to waste, the petals pass through the perforations to the inside of the drum, and then through the fan to the pressure side. The air from the pressure side of the fan is discharged to the atmosphere through a large area of fine-gauge wire mesh; the petals remain inside and are carried along when they settle by a rubberized canvas conveyor to join the hops at the sacking-off point.

Strig separation is effected by a cascade-type of sloping conveyor, similar to that previously described, except that the hops

and strig are fed to the bottom of the conveyor, and there are usually two stages only. A further separation of small pieces of strig takes place on the roller conveyor which carries the hops and strig from the leaf separator to the strig separator, as such small thin rubbish passes through the spaces between the rollers, and is then carried by a further much smaller roller conveyor, situated inside the main one, which discharges to waste. The hand picking stage takes place between the last stage of strig separation and the point at which the petal salved from the leaf separator joins the sample at the bagging-off point.

Provision is made on some Bruff machines for wetting the leaf separating drum, as by doing so stickiness can be reduced and leaf disposal facilitated.

## THE BRUFF "200" MACHINE

This is essentially similar to the "300", except that the picking cylinders are shorter, and mounted horizontally, the bine conveyor being steeper to compensate. The separating mechanism is similar to that of the larger machine.

## THE HARVESTEX MACHINE

This experimental machine works on very different principles from those mentioned above. The form in use during the 1951 season consisted of a bine conveyor somewhat similar to that of conventional machines, but fitted with self-unloading devices on the hooks. The bines were drawn over one or more picking "tubes", or cylinders. The "tube" is the heart of the machine, and has mounted over its circumference a large number of picking orifices. The "tube" rotates and a large fan sucks the hop cones into the picking orifices as the bines are trailed over them. Each picking orifice consists of a stationary split annular knife, with the cutting edge on the inside, over which there rotates a notched guard. The sequence of events is thus: a hop cone is sucked into the orifice, the rotating guard catches its stalk and, with the airstream pulling the cone inwards, combines to press the stalk against the knife blade, severing the stalk. The cone is then carried inside the tube by the airstream and passes, via a leaf separator, out of the airstream and is bagged off.

The leaf separator uses conventional principles, and the main point of the machine is that the actual picking of the hop is carried

out with the least possible mechanical damage to the hop cone. In practice it is visualized that a machine would consist of four or five tubes in series, the bine being drawn over each consecutively, with some means of rotating it between tubes, so that a fresh surface is presented to the next one.

## SCOPE AND DETAILS OF SURVEY

In 1950 a small scale survey was made, by the writers, of some of the machines then in use. This enabled a technique to be evolved whereby the product of one machine could be compared in detail with that of another. In 1951 a full scale survey of twelve machines working in the West Midlands was undertaken with the aid of two teams of four Wye Students in each team, complete with their own cars and special equipment supplied, through the Hop Research Department, Wye College and financed by a special grant from the Agricultural Research Council.

Each team was responsible for all measurements on six machines, each machine being recorded for one day in each week of picking. Each team recorded the following machines :

| | |
|---|---|
| 1 McConnel-Hinds | Plucker Bank |
| 1 ,, ,, | Flying Finger |
| 1 Bruff | Medium |
| 3 ,, | Large |

1. A sample was collected in a tray as the final product was falling into the green sack, i.e. final conveyance for removing picked hops to the kilns for drying. This sample was analysed immediately into :

(*a*) Whole hop.
(*b*) Broken hop. This included : All hops with more than two petals missing, hop strig, hop seed, loose petal.
(*c*) Leaf.
(*d*) Stem.

Each part was weighed separately.

2. At all places where waste material or cleanings were being delivered a sample was taken and analysed into :

(*a*) Hop (Broken or whole).
(*b*) Waste (Leaf, stem, etc.).

Each part was weighed.

3. Ten consecutive strings of bines were collected after they had been machine picked. All hops (whole and broken) and hop strig were removed. The hop, etc., was weighed and the empty string also weighed.

4. A string was collected at random from a particular trailer load. This string was hand picked into the following portions :

(*a*) Hops. (*b*) Leaves. (*c*) Bine.

Each portion was weighed separately.

5. As this particular trailer load was picked by the machine a sample was collected as it was delivered to the green sack.

6. The sample of hand picked hops and the sample of machine picked hops (4 and 5) were put into separate muslin bags and dried. These samples were analysed by Wye College Hop Research Department for resin content.

7. The method of collecting strings in the yard was noted and the actual time taken to load a trailer, including the number of strings, recorded.

8. The number of people engaged and the organization adopted by the grower was recorded.

9. All machine details and any innovations by grower or maker were recorded and the rate at which the strings were fed into the machine was timed.

10. The acreage, total quantity of dried hops obtained and total number of hours the machine worked in the season were recorded.

The sequence of sampling each machine varied according to circumstances, but the general aim was to complete the sequence of samples three times per day.

Finally, a note was made of any particular points of management which appear to influence the efficiency of the machine, the production of a good (dried) sample, or that prevent excessive waste of green hops.

The average results of these analyses stated as percentages are given in tables at the end of this report.

## DISCUSSION OF RESULTS

Reference to the analytical figures shows that most samples are somewhat more broken than would be expected from hand picking. In practice it must be realized that the broken part can

be more nearly whole in some samples than in others ; a hop with only three petals missing is to be preferred to the same hop broken into seed, strig and petal. This further analysis of the broken part of the sample could not be undertaken with the available staff but it is fair to say that on appearance the samples from the Plucker Bank machine are usually more whole than those from other machines.

Extraneous matter is removed both mechanically and by hand, but the final sample still has some extraneous matter in it. This appears, at present, impossible to eliminate completely since large quantities of leaf and stem are picked at the same time as the hops. There is a tendency for the results to show that if a machine is producing a clean final sample the amount of hops lost in waste at the various exits is increased. The inclusion in the sample of this extraneous matter may be treated by brewers with increasing severity, since, not only is it bought at a very high price, but it may be found to have a detrimental effect on the beer. As can be seen from the results it is possible, in certain circumstances, to produce samples containing a very small percentage of extraneous matter, but other samples have a content that is much too high.

The losses of resins in the machine picked samples show considerable variations. As a general rule it appears that some resin is lost by all hops that pass through the machine of present day design. This loss can be small, or may rise to a figure that would be regarded by brewers as excessive. No test was made with hops picked by hand in a commercial manner.

The management of the machine and the different methods adopted in collecting and handling the strings before picking commences appear to have a considerable influence on the efficiency with which the machine picks the hops and also on the weight of dried hops picked per hour.

Growing the hop for the machine must receive particular attention since observation and analysis show that if the string of hops has a small percentage of leaf and stem it is more easy for the machine to produce a good sample. If the string consists of a larger weight of leaf and stem than of hops more difficulty is experienced.

## CONCLUSIONS

Hop-picking machines are now being used on an increasing scale. Due to the extremely short picking season, improvements in design and the introduction of new principles have been very

limited, but it is to be expected that the existing machines will show great improvements in design and operation within the next few years. Care is needed when planning the layout of the building and machine in order to obtain the maximum efficiency from the workers, and to be able to make alterations to the machine as and when modifications are introduced.

The output is governed, in the first instance, by the number of hooks holding strings passing through the machine per minute. It is only efficient team work and organization at this point that can give the best results. This is coupled with the method adopted to collect and haul the bine to the machine. Great care in handling is necessary to prevent breakage before the hops enter the picking mechanism.

The best type of trailer, the gang required in the yard, and the organization of haulage, are all undergoing changes and experimentation. It would appear from the observations made that it is advisable to hang the string, when pulled from the wirework, on a type of removable, but rigid, framework, removing the whole from the trailer at the loading point of the machine. This would facilitate rapid turn round, and continuous loading of hooks without the " tugging and tearing " that takes place with existing methods.

The majority of dried samples picked by machine have a rather " harsh touch " which may be due not only to the broken hop content but also to a large amount of small broken pieces of stem, leaf and loose seed that may be present in the sample. This can only be eliminated by improving the wholeness and keeping the extraneous matter content very low. The principle of applying sufficient pressure to remove the hop from the stem by moving iron fingers of all types needs great skill in application. Growers find it necessary to make day to day adjustments to the speed of the fingers, or to hang strings at varying lengths to get this adjustment. Adjustments of this nature are lengthy and inaccurate, and it is expected that separate adjustment of the plucking tines will eventually be made an integral part of the machine. This should materially assist the wholeness of the sample without reducing the output.

When the hops are picked whole the cleaning apparatus is able to work efficiently but it must also receive the hop stream at a reasonable rate, otherwise overloading prevents the maximum extraction of leaf and stem.

The roller type of lateral picker does not appear to be satisfactory. Considerable breakage of the hop takes place in this

part of the machine, and also a large amount of small broken leaf and stem enters the main hop stream at this point. So far no other method for picking the loose laterals and bunches of hops broken from the main bine has been devised but experiments are now being made with lateral pickers in which the Roller pickers are partially eliminated.

The loss of part of the Total Soft Resin must be considered seriously since the brewer will require some reduction in price if the hops really have less brewing value than the comparable hand picked sample. Further investigation of this problem, including brewing trials, is necessary before any definite conclusions can be reached. As a result of the analysis for resin content it would appear that the more air power used in the cleaning part of the machine the greater the loss of resin. This was also suggested by a series of tests carried out independently a few years ago in Worcester.

Owing to the valuable nature of the hop the standard of hand picking has been very high ; no hop that could be seen was allowed to go to waste. On the machine there is considerably more wastage, which varies both with machine and waste exit. It was impossible to make any large scale tests on this waste, therefore no reliable figures can be given for the total weight of hops lost during the season from any machine. Through observations and some timed measurements made during the survey it is probable that there is excessive waste on all machines at present in use, and it may be as much as 1 cwt. of dried hops per acre. It should be noted, however, that there is no reliable indication of the wastage sustained in hand-picking.

Growing the hop for machine-picking needs investigation ; the variable weather experienced in this country, the susceptibility of the hop to slight variations of soil and the differing systems of stringing adopted, make this problem a complex one. A considerable amount of experiment can be made by the grower but it will become more important, as machine picking spreads, for authoritative work to be carried out on this matter. The aim must be to grow a type of bine, bearing good crops, that can be picked easily and cleanly at all stages of ripeness. It appears that density of cone, strength of bine and lateral, relationship between hop and leaf, and the natural ease with which hops shatter when ripe, are all co-related in the quality of the final sample.

There are in existence new machines that have reached the prototype stage, and others even less well developed, but no comparable tests could be made on them since until they are

working in commercial competition with the existing types their relative values can not be compared.

Finally, this report would be incomplete without recording the whole-hearted co-operation of all the growers who so kindly placed their entire organization at our disposal : we would like to offer our thanks to these growers, to the manufacturers of the machines, and also to the teams of Students of Wye College for their conscientious and careful work.

ABBREVIATIONS USED IN TABLES.

| | |
|---|---|
| W.H. | Whole Hops. |
| B.H. | Broken Hops. Any Hop with more than two petals missing and/or Hop Seed, Hop Strig (Rachis) and Petals. |
| L. | Leaf, however small. |
| St. | Leaf Stem (Petiole) and/or Hop Stem when more than 1 in. long. |
| T.S.R. | Total Soft Resins. |
| α | Alpha Resin. |
| M.P. | Machine Picked. |

## MEDIUM BRUFF.

*Machine A.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 45·1 | 47·0 | 43·0 |
| B.H. .. | 46·0 | 45·8 | 49·5 |
| L. .. | 6·5 | 5·9 | 5·9 |
| St. .. | 2·25 | 1·3 | 1·5 |

COMBINED WASTE

| | | | |
|---|---|---|---|
| Hops in Waste .. | 9·1 | 9·0 | 23·8 |

10 STRIPPED STRINGS

| | | | |
|---|---|---|---|
| Hops in Waste .. | 0·46 | 0·94 | 0·86 |

COLLECTION OF STRINGS IN YARD

| | | | |
|---|---|---|---|
| No. of Strings | 79 | 60 | 59 |
| Time in Min. .. | 7·6 | 2½ | 3·25 |

RATE OF FEEDING STRINGS

| | | | |
|---|---|---|---|
| Per Min. | 7 | 12–13 | 12 |

HAND PICKED STRING

| | | | |
|---|---|---|---|
| Hops .. | 50·5 | 47·5 | 56·8 |
| L. .. | 26·5 | 27·7 | 21·7 |
| St. .. | 22·7 | 24·5 | 21·0 |

PRESERVATIVE VALUE

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 12·04 | 10·24 | — 1·8 |
| α % * | 4·60 | 3·91 | — 0·69 |
| 2nd Week | | | |
| T.S.R. % * | *11·24 | 9·55 | — 1·69 |
| α % * | *4·24 | 3·47 | — 0·77 |
| 3rd Week | | | |
| T.S.R. % * | 12·31 | 10·94 | — 1·37 |
| α % * | 4·05 | 3·38 | — 0·67 |

CARRYING EQUIPMENT

2 Tractors (Wheel)
2 Trailers fitted with Sheets for unloading
Waste removed to yard by these Trailers
Average distance to Yard Centre 950 yards.

YARD ORGANIZATION

2 Tractor Drivers
2 Cutting and Loading Strings
3 Collecting Dropped Hops, etc.

MACHINE ORGANIZATION

2 Feeding Strings on Hooks
1 Removing String from Hooks
5 Cleaning Final Sample
1 Bagging Off
2 Attending Lateral Picker
1 Attending Strig Waste
2 Attending Main Waste Conveyor
1 Mechanic

Acreage of Hops = 17½
Total Quantity Picked = 294 cwt. Dried Hops
Total No. of Machine Hours = 181
Quantity picked per hour = 1·6 cwt.
Hours worked per ton Dried Hops = 12·5.

* Calculated on "Moisture Free" Hops.

## MEDIUM BRUFF.

*Machine B.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Mathons Av. % |
|---|---|---|---|
| W.H. .. | 49·1 | 46·2 | 42·0 |
| B.H. .. | 42·0 | 46·5 | 48·3 |
| L. .. | 7·2 | 5·8 | 7·2 |
| St. .. | 1·6 | 1·5 | 2·4 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 4·25 | 6·8 | 8·1 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 0·36 | 0·37 | 0·9 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 170 | 125 | 153 |
| Time in Min. .. | 10 | 10 | 12¾ |

### Rate of Feeding Strings

| | | | |
|---|---|---|---|
| Per Min. | 13 | 10 | 11 |

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | 55·0 | 47·5 | 54·5 |
| L. .. | 21·5 | 26·75 | 23·5 |
| St. .. | 23·5 | 25·25 | 22·0 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 10·99 | 10·39 | — 0·6 |
| α % * | 4·28 | 3·09 | — 1·19 |
| 2nd Week | | | |
| T.S.R. % * | 11·75 | 10·90 | — 0·85 |
| α % * | 4·59 | 3·84 | — 0·75 |
| 3rd Week | | | |
| T.S.R. % * | 11·34 | 9·55 | — 1·79 |
| α % * | 4·02 | 2·55 | — 1·47 |

### Carrying Equipment

2 Tractors (Wheel)
3 and 4 Trailers, depending on length of haul.
(1 Tractor and Trailer used to take away bine.)
(Distance from yard varied from 800-1,200 yards.)

### Yard Organization

2 Tractor Drivers
2 Pulling and Loading Strings
1 Cutting Bine and Collecting Dropped Hops.

### Machine Organization

2 Feeding Strings on Hooks
1 Removing Strings from Hooks
7 Cleaning Final Sample
1 Bagging Off
2 Attending Lateral Pickers
1 Attending Leaf Waste
1 Mechanic
1 General Help

Acreage of Hops = 16½
Total Quantity Picked = 255 cwt. Dried Hops
Total No. Machine Hours = 156
Quantity picked per hour = 1·6 cwt. Dried Hops
Hours worked per ton Dried Hops = 12·5

* Calculated on "Moisture Free" Hops.

## LARGE BRUFF.

*Machine C.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 44·3 | 49·7 | 49·5 |
| B.H. .. | 48·9 | 42·0 | 44·0 |
| L. .. | 5·4 | 6·3 | 4·7 |
| St. .. | 1·3 | 1·9 | 1·7 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 14·2 | 14·7 | 9·8 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 2·2 | 1·4 | 1·2 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 108 | 94 | 142 |
| Time in Mins. .. | 6 | 5½ | 7½ |

### Rate of Feeding Strings

| | | | |
|---|---|---|---|
| Per Min. | 12 | 12 | 12–13 |

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | 51·0 | 51·0 | 50·5 |
| L. .. | 29·5 | 25·5 | 21·8 |
| St. .. | 19·5 | 23·5 | 27·5 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 11·00 | 10·72 | — 0·28 |
| α % * | 3·80 | 3·69 | — 0·11 |
| 2nd Week | | | |
| T.S.R. % * | 12·36 | 10·66 | — 1·70 |
| α % * | 4·73 | 3·64 | — 1·09 |
| 3rd Week | | | |
| T.S.R. % * | 10·24 | 11·05 | + 0·81 |
| α % * | 3·75 | 3·51 | — 0·24 |

### Carrying Equipment

2 Wheel Tractors
2 Trailers fitted with Platforms
(Empty Bine and Waste carted away by these Trailers)
Distance to Yard = 400 yards

### Yard Organization

2 Tractor Drivers
2 Cutting Top of String
1 Cutting Bottom
2 Loading Trailer
1 Collecting Dropped Hops

### Machine Organization

3 Feeding Strings on Hooks
1 Removing Strings from Hooks
1 Feeding Picked Strings to Chaff Cutter
1 Removing Hops from Picked Bine
6 Cleaning Final Sample
1 Bagging Off
4 Attending Lateral Pickers
1 Attending Waste Conveyor
3 Attending Strig Conveyor
1 Mechanic

Acreage of Hops = 33
Total Quantity Picked = 342 cwt. Dried Hops
Total No. of Machine Hours = 162
Quantity picked per hour = 2·1 cwt. Dried Hops
Hours worked per ton Dried Hops = 9·5

* Calculated on "Moisture Free" Hops.

## LARGE BRUFF.

*Machine D.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 45·2 | 42·3 | 48·3 |
| B.H. .. | 47·1 | 49·7 | 41·9 |
| L. .. | 6·7 | 6·9 | 7·8 |
| St. .. | 0·99 | 1·1 | 2·0 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 7·8 | 20·3 | 14·9 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 0·83 | 0·57 | 1·4 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 92 | 145 | 50 |
| Time in Mins. .. | 3·3 | 4 | 3 |

### Rate of Feeding Strings

| | | | |
|---|---|---|---|
| Per Min. | 9–11 | 14–15 | 14 |

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | 53·4 | 58·2 | 45·1 |
| L. .. | 25·8 | 21 4 | 29 9 |
| St. .. | 20 8 | 20·4 | 25·0 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 14·32 | 11·79 | — 2·53 |
| α % * | 5·2 | 4·14 | — 1·06 |
| 2nd Week | | | |
| T.S.R. % * | 12·11 | 11·18 | — 0·93 |
| α % * | 4·15 | 3·77 | — 0·38 |
| 3rd Week | | | |
| T.S.R. % * | 12·39 | 10·86 | — 1·53 |
| α % * | 4·61 | 3·31 | — 1·30 |

### Carrying Equipment

3 Tractors (Wheel)
3 Trailers
(Waste removed by separate Tractor and Trailer)
Distance to Yard Centre=550 yards

### Yard Organization

1 Cutting Strings
2 Pulling and Loading on Trailer
2 Pulling on Ground
2 Cleaning up Dropped Hops

### Machine Organization

2 Loading Hooks
2 Unloading Hooks and Removing Hops
6 Cleaning Final Sample
2 Bagging Off
2 Attending Lateral Pickers
1 Main Waste Conveyor
3 Strig Waste Conveyors
1 Mechanic

Acreage of Hops=22
Total Quantity Picked=228 cwt. Dried Hops
Total No. Machine Hours=105
Quantity picked per hour=2·1 cwt. Dried Hops
Hours worked per ton Dried Hops=9·5

* Calculated on "Moisture Free" Hops.

## LARGE BRUFF.

*Machine E.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 52·2 | 46·0 | 45·7 |
| B.H. .. | 41·0 | 43·5 | 45·1 |
| L. .. | 5·6 | 8·1 | 7·2 |
| St. .. | 0·9 | 2·3 | 2·0 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 21·0 | 15·2 | 15·0 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 3·0 | 2·2 | 2·0 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 274 | 171 | 147 |
| Time in Min. .. | 20·7 | 19·6 | 22·6 |

### Rate of Feeding Strings

| | | | |
|---|---|---|---|
| Per Min. | 13 | 10–11 | 12–13 |

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | 54·4 | 53·2 | 52·0 |
| L. .. | 21·7 | 21·2 | 24·2 |
| St. .. | 23·5 | 25·3 | 23·7 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 13·36 | 9·63 | — 3·73 |
| α % * | 4·84 | 3·74 | — 1·10 |
| 2nd Week | | | |
| T.S.R. % * | 11·57 | 10·31 | — 1·26 |
| α % * | 4·28 | 3·47 | — 0·81 |
| 3rd Week | | | |
| T.S.R. % * | 13·93 | 11·44 | — 2·49 |
| α % * | 4·65 | 2·90 | — 1·75 |

### Carrying Equipment

2 Tractors (Wheel)
5 Trailers
(Trailer loaded by twisting bine into ball with butt on top)
(All waste and spent bine cut and blown into heap from machine)
Distance to Yard Centre = 685 yards

### Yard Organization

2 Tractor Drivers
4 Pulling and Loading
2 Picking up and cutting down (working in two separate gangs)

### Machine Organization

3 Loading Strings on Hooks
3 Unloading Strings from Hooks and Feeding Cutter Blower
4 Cleaning Final Sample
2 Bagging Off
1 Attending Lateral Picker
1 Attending Bines entering Machine
2 Attending Strig Waste
1 Mechanic

Acreage of Hops = 27
Total Quantity picked = 349 cwt. Dried Hops
Total No. Machine Hours = 119½
Quantity picked per hour = 2·9 cwt. Dried Hops
Hours worked per ton Dried Hops = 6·9

* Calculated on "Moisture Free" Hops.

## LARGE BRUFF.

*Machine F.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 39·0 | 43·5 | 41·0 |
| B.H. .. | 52·5 | 51·7 | 52·0 |
| L. .. | 6·2 | 3·6 | 4·8 |
| St. .. | 2·2 | 1·2 | 2·2 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 9·4 | 9·5 | 7·9 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 2·5 | 0·5 | 1·3 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 87½ | 105 | 109 |
| Time in Min. | 8¾ | 7½ | 6½ |

### Rate of Feeding Strings

| | | | |
|---|---|---|---|
| Per Min. | 14 | 10–11 | 12 |

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | | 53·0 | 53·0 |
| L. .. | | 19·0 | 20·5 |
| St. .. | | 28·0 | 26·5 |

### Preservative Value.

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % | 10·67 | 9·68 | — 0·89 |
| α % * | 4·46 | 3·59 | — 0·87 |
| 2nd Week | | | |
| T.S.R. % | 11·25 | 10·20 | — 1·05 |
| α % * | 4·66 | 3·78 | — 0·88 |
| 3rd Week | | | |
| T.S.R. % | 11·26 | 11·14 | — 0·12 |
| α % * | 4·05 | 3·31 | — 0·74 |

### Carrying Equipment

3 Tractors (Wheel)
4 Trailers
(Empty bine carried away by these Tractors and Trailers)
Distance to Yard = 760 yards

### Yard Organization

3 Tractor Drivers
1 Cutting and Pulling
1 Loading
1 Collecting Dropped Hops

### Machine Organization

2 Feeding Strings on Hooks
2 Removing Strings from Hooks and Picking up Hops
8 Cleaning Final Sample
1 Bagging Off
2 Attending Lateral Picker
2 Attending Leaf Cleaner
2 Attending Strig Waste
1 Clearing up Bine and Strig Waste
1 Mechanic

Acreage of Hops = 35½
Total Quantity picked = 424 cwt. Dried Hops
Total No. of Machine hours = 206
Quantity picked per hour = 2 cwt. Dried Hops
Hours worked per ton Dried Hops = 10

* Calculated on "Moisture Free" Hops.

## LARGE BRUFF.

*Machine G.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % | 4th Week Fuggle Av. % |
|---|---|---|---|---|
| W.H. .. | 58·5 | 38·1 | 56·3 | 47·3 |
| B.H. .. | 30·6 | 48·4 | 35·5 | 44·8 |
| L. .. | 8·8 | 11·0 | 6·7 | 6·2 |
| St. .. | 2·1 | 2·4 | 1·5 | 1·7 |

### Combined Waste

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 10·0 | 7·2 | 8·3 | 13·4 |

### 10 Stripped Strings

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 5·4 | 1·9 | 1·2 | 1·1 |

### Collections of Strings in Yard

| | | | | |
|---|---|---|---|---|
| No. of Strings .. | 106 | 68 | 105 | 89 |
| Time in Mins. .. | 6 | 5·6 | 7 | 4½ |

### Rate of Feeding Strings

| | | | | |
|---|---|---|---|---|
| Per Min. .. | 13 | 11 | 11 | 8 |

### Hand Picked String

| | | | | |
|---|---|---|---|---|
| Hops .. | 55·3 | 50·1 | 46·7 | 50·0 |
| L. .. | 32·1 | 24·8 | 28·9 | 26·6 |
| St. .. | 12·6 | 25·1 | 24·4 | 23·4 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 11·40 | 10·61 | — 0·79 |
| α % * | 4·95 | 3·85 | — 1·10 |
| 2nd Week | | | |
| T.S.R. % * | 13·41 | 11·42 | — 1·99 |
| α % * | 5·18 | 3·73 | — 1·45 |
| 3rd Week | | | |
| T.S.R. % * | 13·69 | 11·76 | — 1·93 |
| α % * | 5·48 | 4·46 | — 1·02 |
| 4th Week | | | |
| T.S.R. % * | 11·50 | 11·50 | — — |
| α % * | 4·35 | 3·87 | — 0·48 |

### Carrying Equipment

3 Tractors (Wheel)
3 Trailers
(All waste carted to yard by these tractors and one trailer)
Distance to Yard Centre = 800 yards

### Yard Organization

1 Cutting Strings and Picking up Hops
2 Pulling and loading strings
3 Tractor Drivers

### Machine Organization

2 Feeding Hooks
2 Taking off Hooks and Picking off hops
7 Cleaning Final Sample
1 Bagging Off
4 Attending Lateral Pickers
4 Picking Extra Laterals
2 Attending Strig Waste
1 General Cleaner, etc.
1 Mechanic

Acreage of Hops = 27
Total quantity picked = 448 cwt. Dried Hops
Total No. Machine hours = 170
Quantity picked per hour = 2·63 cwt. Dried Hops
Hours worked per ton of Dried Hops = 7·7

* Calculated on "Moisture Free" Hops.

*Machine H.*

| Variety | 1st Early Bird Av. % | 2nd Mathon Av. % | 3rd Mathon Av. % | 4th Mathon Av. % |
|---|---|---|---|---|
| W.H. .. | 52·8 | 58·9 | 68·3 | 51·4 |
| B.H. .. | 40·0 | 36·4 | 27·7 | 40·6 |
| L. .. | 4·9 | 2·1 | 2·8 | 6·3 |
| St. .. | 2·3 | 2·6 | 1·2 | 1·7 |

LATERAL WASTE

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 18·8 | 7·3 | 19·9 | 11·1 |

STRIG WASTE

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 7·1 | 37·8 | 12·5 | 17·0 |

LEAF EXTRACTOR

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 13·2 | 15·4 | 13·9 | 10·5 |

10 STRIPPED STRINGS

| | | | | |
|---|---|---|---|---|
| Hops in Waste .. | 3·0 | 3·0 | 3·6 | 2·6 |

RATE OF FEEDING STRINGS

| | | | | |
|---|---|---|---|---|
| Per Min. .. | 7–10 | 13 | 13 | 13 |

COLLECTION OF STRINGS IN YARD

| | Gang I | Gang II |
|---|---|---|
| No. of Strings .. | 188 | 110 |
| Time in Mins. .. | 16¾ | 17 |

HAND PICKED STRINGS

| | | | | |
|---|---|---|---|---|
| Hops .. | 53·1 | 58·3 | 61·7 | 36·2 |
| L. .. | 23·7 | 20·1 | 16·2 | 32·2 |
| St. .. | 23·2 | 21·6 | 22·1 | 31·6 |

PRESERVATIVE VALUE.

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 13·78 | 11·50 | — 2·28 |
| α % * | 6·07 | 4·89 | — 1·18 |
| T.S.R. % * | 12·55 | 11·95 | — 0·60 |
| α % * | 5·12 | 4·90 | — 0·22 |
| 2nd Week | | | |
| T.S.R. % * | 13·84 | 12·12 | — 1·72 |
| α % * | 6·15 | 5·40 | — 0·75 |
| 3rd Week | | | |
| T.S.R. % * | 13·0 | 10·76 | — 2·24 |
| α % * | 5·49 | 4·71 | — 0·78 |
| 4th Week | | | |
| T.S.R. % * | 14·14 | 12·49 | — 1·65 |
| α % * | 5·61 | 4·41 | — 1·20 |

CARRYING EQUIPMENT

1 Crawler Tractor
2 Wheel Tractors
3 Double Trailers
4 Large Trailers
Distance to Centre of Yard = 600 yards
(Waste removed by Separate Tractor and Trailers)

YARD ORGANIZATION

*Gang I*
2 Tractor Drivers
2 Cutting Top
2 Loading Trailers
1 Cutting on Ground
4 Picking up Hops
4 Stripping Head (Hand Picking)

*Gang II*
1 Tractor Driver
2 Cutting, Pulling, Loading

MACHINE ORGANIZATION

3 Feeding Hooks
3 Taking off Hooks, Feeding Chaff Cutter and Picking off Hops
8 Cleaning Final Sample
2 Bagging Off
2 Attending Lateral Picker
1 Attending Strig Waste
2 Removing Leaf and Strig Wastes
1 Mechanic
9 Hand-Picking Excess Lateral.

*Gang I*
Crawler Tractor with platform, 2 men on platform cut strings at top wire and hand to 2 loaders on trailers. Trailers carted away by wheeled tractor.

*Gang II*
1 Wheel Tractor Collecting Strings and taking load to machine

Acreage of Hops = 39·5
Total Quantity Picked = 519 cwt. Dried Hops
Total No. Machine hours = 200½
Quantity Picked per hour = 2·6 cwt. Dried Hops
Number of hours per ton Dried Hops = 7·7

* Calculated on "Moisture Free" Hops.

## McCONNEL-HINDS FLYING FINGER.

*Machine I.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Mathons Av. % | 3rd Week Fuggle Av. % | 4th Week Fuggle Av. % |
|---|---|---|---|---|
| W.H. | 43·9 | 44·3 | 37·4 | 32·7 |
| B.H. | 48·9 | 44·3 | 53·5 | 58·6 |
| L. | 5·2 | 6·9 | 5·1 | 4·6 |
| St. | 1·9 | 4·5 | 4·0 | 3·3 |

### Combined Waste

| | | | | |
|---|---|---|---|---|
| Hops in Waste | 23·3 | 9·1 | 9·6 | 13·5 |

### 10 Stripped Strings

| | | | | |
|---|---|---|---|---|
| Hops in Waste | 1·45 | 3·9 | 1·04 | 2·41 |

### Collection of Strings in Yard

| | | | | |
|---|---|---|---|---|
| No. of Strings | 123 | 192 | 246 | 234 |
| Time in Mins. | 11·1 | 8½ | 11½ | 11½ |

### Rate of Feeding Strings

| | | | | |
|---|---|---|---|---|
| Per Min. | 7–13 per bank (2 banks) | 10 per bank | 13 per bank | 13 per bank |

### Hand Picked Strigs

| | | | | |
|---|---|---|---|---|
| Hops | 64·9 | 52·1 | 54·7 | 53·3 |
| L. | 16·8 | 22·8 | 15·8 | 17·9 |
| St. | 18·3 | 25·1 | 29·5 | 28·8 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % | 13·14 | 11·29 | — 1·85 |
| α % * | 4·26 | 4·19 | — 0·07 |
| 2nd Week | | | |
| T.S.R. % | 12·44 | 11·05 | — 1·39 |
| α % * | 4·86 | 4·20 | — 0·66 |
| 3rd Week | | | |
| T.S.R. % | 12·66 | 10·48 | — 2·18 |
| α % * | 5·05 | 3·94 | — 1·11 |
| 4th Week | | | |
| T.S.R. % | 13·98 | 11·72 | — 2·26 |
| α % * | 5·19 | 3·63 | — 1·56 |

### Carrying Equipment

3 Tractors
6 Trailers (used in pairs)
(Average distance to yard = 1,000 yards)
Waste removed to adjoining Field by one Tractor and one Trailer
1 Horse and Cart (occasional)

### Yard Organization

3 Tractor Drivers
2 Pulling and Loading Strings
1 Cutting Strings
1 Picking up Hops, etc.

### Machine Organization

4 Feeding Strings on Hooks
2 Cutting Off Surplus Strings, etc.
2 Taking off Hooks
18 Cleaning Final Sample
2 Bagging Off
2 Attending Lateral Pickers
1 Mechanic

Acreage of Hops = 51
Total Quantity = 493 cwt. Dried Hops
Total No. Machine hours = 180
Quantity Dried Hops per hour = 2·7 cwt.
Hours worked per ton Dried Hops = 7·4

* Calculated on "Moisture Free" Hops.

## McCONNEL-HINDS, FLYING FINGER.

*Machine J.*

| | 1st Week Fuggle Av. % | 2nd Week Fuggle Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 30·9 | 39·8 | 41·6 |
| B.H. .. | 59·5 | 50·6 | 46·4 |
| L. .. | 6·8 | 6·2 | 8·8 |
| St. .. | 2·8 | 3·4 | 3·2 |

### Combined Waste

| | | | |
|---|---|---|---|
| Hops in Waste .. | 6·1 | 12·0 | 6·3 |

### 10 Stripped Strings

| | | | |
|---|---|---|---|
| Hops in Waste .. | 0·6 | 2·3 | 1·4 |

### Collection of Strings in Yard

| | | | |
|---|---|---|---|
| No. of Strings | 137 | 104 | 153 |
| Time in Mins. .. | 5¼ | 2¼ | 2½ |

### Rate of Feeding Strings

| Per Min. | 11–12 per bank (2 banks) | 11–12 per bank | 8–9 per bank |
|---|---|---|---|

### Hand Picked String

| | | | |
|---|---|---|---|
| Hops .. | 48·5 | 56·0 | 50·3 |
| L. .. | 27·4 | 21·7 | 26·5 |
| St. .. | 24·1 | 22·3 | 23·2 |

### Preservative Value

| | Hand Picked | Machine Picked | M.P. Gain or Loss |
|---|---|---|---|
| 1st Week | | | |
| T.S.R. % * | 13·11 | 11·51 | — 1·60 |
| α % * | 4·80 | 3·70 | — 1·10 |
| 2nd Week | | | |
| T.S.R. % * | 11·84 | 10·12 | — 1·72 |
| α % * | 3·54 | 3·59 | + 0·05 |
| 3rd Week | | | |
| T.S.R. % * | 9·73 | 10·92 | + 1·19 |
| α % * | 2·95 | 3·97 | + 1·02 |

### Carrying Equipment

3 Tractors
5 Trailers with Sheets
(Waste Bine. etc., carted to yard by these trailers)
Average distance to Yard Centre = 700 yds.

### Yard Organization

3 Tractor Drivers
2 Cutting, and Picking up Hops
2 Pulling and Loading Trailers

### Machine Organization

4 Loading Hooks
2 Cutting Spare String, etc., before Bine enters machine
2 Unloading Hooks
21 Cleaning Final Sample
2 Bagging Off
2 on Waste Loading
1 Mechanic

Acreage of Hops = 60
Total Quantity Picked = 780 cwt. Dried Hops
Total No. Machine Hours = 278
Quantity Picked per hour = 2·8 cwt. Dried Hops
Hours per ton Dried Hop = 7·1

* Calculated on "Moisture Free" Hops.

*Machine K.*

| Variety | 1st Week Fuggle Av. % | 2nd Week Mathon Av. % | 3rd Week Fuggle Av. % |
|---|---|---|---|
| W.H. .. | 54·7 | 59·3 | 63·5 |
| B.H. .. | 39·3 | 33·2 | 30·7 |
| L. .. | 4·2 | 4·4 | 3·2 |
| St. .. | 1·8 | 3·1 | 2·6 |

LATERAL WASTE

| | | | |
|---|---|---|---|
| Hops in Waste .. | 10·0 | 10·0 | 4·2 |

LEAF WASTE

| | | | |
|---|---|---|---|
| Hops in Waste .. | 8·4 | 10·0 | 5·6 |

10 STRIPPED STRINGS

| | | | |
|---|---|---|---|
| Hops in Waste .. | 1·3 | 0·55 | 0·29 |

COLLECTION OF STRINGS IN YARD

| | | | |
|---|---|---|---|
| No. of Strings | 80 | 70 | 73 |
| Time in Mins. .. | 3¾ | 4½ | 5 |

RATE OF FEEDING STRINGS

| | | | |
|---|---|---|---|
| Per Min. | 9–10 per bank (2 banks) | 8 per bank | 8 per bank |

HAND PICKED STRING

| | | | |
|---|---|---|---|
| Hops .. | 54·0 | 53·8 | 46·3 |
| L. .. | 22·6 | 23·5 | 23·5 |
| St. .. | 23·4 | 22·7 | 30·2 |

PRESERVATIVE VALUE

| | Hand Picked | Machine Picked | Gain or Loss | M.P. |
|---|---|---|---|---|
| 1st Week | | | | |
| T.S.R. % | 12·45 | 11·61 | — | 0·84 |
| α % * | 4·69 | 4·42 | — | 0·27 |
| 2nd Week | | | | |
| T.S.R. % | 12·06 | 12·30 | + | 0·24 |
| α % * | 4·53 | 4·44 | — | 0·09 |
| 3rd Week | | | | |
| T.S.R. % | 10·48 | 11·60 | + | 1·12 |
| α % * | 3·97 | 3·93 | — | 0·04 |

CARRYING EQUIPMENT

2 Tractors
2 Trailers fitted with Sheets
Distance to Yard Centre=580 yards
Waste removed to Dump by 2 men, 2 horses and 4 carts

YARD ORGANIZATION

2 Tractor Drivers
4 Pulling, Cutting and Picking up Hops (working in two gangs, i.e. 1 Tractor and Driver and 2 men per Gang)

MACHINE ORGANIZATION

2 Feeding Hooks
2 Unloading Hooks
6 Attending Plucker Banks
18 Cleaning Final Sample
2 Bagging Off
1 Mechanic

Acreage of Hops=26
Total Quantity Picked=435 cwt. Dried Hops
Quantity Picked per hour=2·7 cwt. Dried Hops
Hours worked per ton Dried Hops=7·2

* Calculated on "Moisture Free" Hops.

## McCONNEL-HINDS, PLUCKER BANK.

*Machine L.*

| Variety | 1st Week Northern Brewer | 2nd Week O.K.40 Concord John Ford | 3rd Week Variety Bullion |
|---|---|---|---|
| | Final Sample Av. % | Final Sample Av. % | Final Sample Av. % |
| W.H. .. | 71·0 | 67·7 | 81·8 |
| B.H. .. | 26·7 | 27·6 | 14·7 |
| L. .. | 1·2 | 2·6 | 2·1 |
| St. .. | 1·1 | 2·1 | 1·4 |
| **Lateral Waste** | | | |
| Hops in Waste .. | 12·4 | 14·1 | 8·4 |
| **Extracted Petal** | | | |
| W.H. .. | 5·4 | 7·4 | 12·0 |
| B.H. .. | 58·5 | 67·2 | 63·5 |
| L. .. | 23·7 | 17·5 | 18·5 |
| St. .. | 12·4 | 7·9 | 6·0 |
| **Waste from Petal Extraction** | | | |
| Hops in Waste .. | 6·7 | 12·5 | 5·5 |
| **10 Stripped Strings** | | | |
| Hops in Waste .. | 0·9 | 1·2 | 0·37 |
| **Collection of String in Yard** | | | |
| No. of Strings | 180 | 175 | 150 |
| Time in Min. .. | 19 | 11·25 | 4¾ |
| **Rate of Feeding Strings** | | | |
| Per Min. | 7 per bank (2 banks) | 6 per bank | 4 per bank |
| **Hand Picked String** | | | |
| Hops .. | 56·1 | 54·5 | 50·7 |
| L. .. | 21·8 | 21·0 | 25·7 |
| St. .. | 22·1 | 24·5 | 23·5 |

**Carrying Equipment**

3 Horses
3 Drays
(Distance to Centre of Yard = 700 yards)
(All waste carted by separate horse and dray for compost)

**Yard Organization**

3 Pulling and Loading Hops
1 Picking Up Hops
1 Cutting Strings

**Machine Organization**

2 Feeding Hooks
2 Removing from Hooks
2 Attending Plucker Banks
11 Cleaning Final Sample
2 Attending Lateral Pickers
1 Attending Extra Lateral Pickers
1 Bagging Off
1 Mechanic Supervisor

Acreage of Hops = 37
Dried cwt. = 705½ cwt.
Machine Hours = 301¾
2·3 cwt. per hour (Dried Hops)
8·7 hours per ton (Dried Hops)

| | Preservative Value | | | | Variety |
|---|---|---|---|---|---|
| | Hand Picked | Machine Picked | M.P. Gain or Loss | | |
| 1st Week | | | | | |
| T.S.R. % | 19·55 | 17·42 | — | 2·13 | Northern Brewer |
| α % * | 9·88 | 8·31 | — | 1·57 | |
| 2nd Week | | | | | |
| T.S.R. % | 20·05 | 18·70 | | 1·35 | John Ford Hop |
| α % * | 10·00 | 9·34 | — | 0·66 | |
| T.S.R. % | 12·44 | 8·24 | — | 4·20 | Concord |
| α % | 4·32 | 3·30 | — | 1·02 | |
| T.S.R. % | 16·84 | 17·82 | + | 0·98 | Pride of Kent |
| α % | 6·40 | 6·78 | + | 0·38 | |
| T.S.R. % | 13·76 | 13·50 | — | 0 26 | OK40 |
| α % | 6 12 | 5·81 | — | 0·31 | |
| 3rd Week | | | | | |
| T.S.R. % | 17·86 | 15·50 | — | 2·36 | Bullion Hop |
| α % * | 6·95 | 6·63 | – | 0·32 | |

* Calculated on "Moisture Free" Hops.

# VARIABILITY IN CANADIAN WILD HOPS

S. O. S. Dark

The characteristics of wild hop populations and the range of variation which they exhibit have not received much attention in the past. The only published account is Salmon and Wormald's (1921) study of seedlings raised from wild Italian plants.

Two wild hops have been introduced from America and used by Salmon in breeding the Wye New Varieties. One of these was the variety *Humulus lupulus var. neomexicanus*, and the other was the wild hop found growing in Manitoba, which was at one time called *H. americanus* but was later considered to be merely a form of *H. lupulus*. The original Manitoba plants introduced to Wye, were extremely susceptible to Downy Mildew disease and died in their second year, before any information could be obtained concerning their cropping habits, richness in resins, etc. Fortunately open pollinated seed was collected from one individual numbered BB1. The only notes about the plant state that it was " weak growing, with pointed cone which was rough and ugly ". However, two of the seedlings from this plant were Brewer's Gold and Bullion, while many other of the Wye New Varieties have been derived from it by further breeding.

The success of this individual plant as a parent, in conjunction with the richness in resins and strong aroma of the American commercial hops, has induced the general acceptance of the hypothesis that the indigenous American hops are rich in resins and possess the strong " black currant " aroma.

That this hypothesis is ill founded was suggested by our findings in the search for varieties of hops resistant to *Verticillium* Wilt. Practically all the seedlings so far found which possess reasonable resistance to this disease are descended from BB1 and from the *Neo-mexicanus* variety. BB1 was, of course, never tested for resistance, but our clone of *neo-mexicanus*, besides having poor resins ($4 \cdot 5\alpha : 7 \cdot 46\beta$) is definitely susceptible to *Verticillium* Wilt, thus resembling the commercial varieties grown in this country and also the wild European hop from Italy. A wild male obtained from Ottowa is also susceptible to this disease, while the female HH35 has poor resins ($1 \cdot 5\alpha : 6 \cdot 06\beta$). These results indicate that

neither the high resin factor nor that giving resistance to *Verticillium* Wilt is present as such in the wild American varieties, but that the American and European stocks contain complementary genes which when brought together in hybrids, develop the useful characters of disease resistance, high resins content, etc.

In order further to investigate the characteristics of the Canadian wild hops, a collection of cuttings was obtained in 1948 by Mr. Hargrave from the Assinoboine River—a perfectly wild habitat in Manitoba. Of these, 5 female, 3 male and 2 monoecious plants were established in the Nursery garden. In case they emulated their predecessors and succumbed rapidly to Downy Mildew attack, open pollinated seed was collected from each individual.

So that we could see what range of variation is present in the wild Canadian stock, crosses were made between individual plants in an endeavour to raise pure bred Canadian families. We could not obtain absolute control of pollination because the plants did not produce large enough fertile lateral branches for rooting in the pressurized house. The results, however, indicate that the muslin sleeves which were used instead, provided very good protection of the burr from contaminant pollination.

Two hundred seeds from each of these pollinations were sown in the normal way in the spring of 1952 (except in two cases where the totals of seeds are given in square brackets). The curious germination results are summarized in Table 1.

All the seeds that were sown appeared to be well developed and plump and did not collapse when pinched between the finger and thumb at sowing time. The germination differences therefore

Table 1

| % germination from open pollinated seed | Parents ♀ | Parents ♂ | % germination from crossed seed |
|---|---|---|---|
| 7·5 | FF100 | FF103 | 0 |
| 47·0 | FF63 | FF103 | †0·5 |
| 6·1 [197] | GG107 | GG24 | 0 [14] |
| 70·5 | GG54 | GG24 | 0 |
| 80·0 | HH45 | GG104 | 82·0 |
| 68·5 | EE28 | | |
| 7·0 | HH35 | | |
| 39·0 | HH63 | | |
| 55·5 | HH86 | | |

† This single plant was a feeble dwarf.

cannot be attributed to the use of poor seed. A later examination of some of the unused seeds from each batch, showed that the embryos in the sterile group of seeds looked perfectly developed and healthy, although slightly smaller than those from the group which germinated.

## Conclusions

1. Further experiments will be necessary to determine the mechanism and mode of inheritance of this sterility.

2. The effect is not due to the interaction of incompatibility groups, such as are found in cherries and many other plants, because the action comes after seed production instead of preventing it (Lewis, 1949).

3. A number of sterility factors must be segregating in the wild Canadian hop population since the percentage of germinable seed produced is variable and can be controlled by both parents.

4. The sterility reactions and their vegetative characters make it very probable that the female plants FF100 and GG107 are clones of the same individual.

## References

Lewis, D. 1949. "Incompatibility in flowering plants." *Biol. Rev.*, **24**, 472-495.

Salmon, E. S. and Wormald, H. 1921. "A study of the variation in seedlings of the wild hop (*Humulus lupulus* L.)" *Jour. Gen.*, **11**, 241-267.

# THE CHALLENGE CUPS FOR NEW VARIETIES OF HOPS

Professor E. S. Salmon

This Competition is now divided into three Classes: (1) The Brewers' Cup, for hops intended as substitutes for American hops; this Challenge Cup was offered in 1944 by Messrs. Barclay, Perkins, Messrs. Guinness and Messrs. Whitbread; (2) the Growers' Cup, for hops intended to augment English commercial varieties; this Cup was offered in 1946 by the Association of Growers of the New Varieties of Hops; (3) the Hop Merchants' Association's Cup, offered in 1949 by this Association for New Varieties certified as showing resistance to *Verticillium* Wilt.

The eighth Competition was held, under the auspices of the Institute of Brewing, in the showrooms of Messrs. Wigan, Richardson and Co., 15 Southwark Street, London, on November 28th and 29th, 1951, the Judges being Messrs. Simon Combe, S. Myer and D. Le May. A list of the Entries is given in Tables 1-3, together with the analyses which were carried out at Wye College, between November 5th and 16th, by Mr. A. R. Tatchell, M.Sc., under the direction of Dr. A. H. Burgess.

The Brewers' Cup was awarded to Mr. E. M. Gorst, for a sample of Bullion Hop (Q43); a sample of the same variety grown by Furnace Farms, Ltd., was placed second. The Growers' Cup was awarded to Messrs. A. & K. J. Amos, for a sample of Pride of Kent (170*a*); a sample of the same variety grown by Messrs. Chambers (Sevenoaks) was placed second. The Hop Merchants' Association's Cup was awarded to H. J. Highwood, Ltd., for a sample of Keyworth's Midseason (OR55).

The samples of Bullion Hop (Q43) placed first and second gave analyses of 7·91 per cent. $\alpha$-acid, 10·81 per cent. $\beta$-resins and 7·99 per cent. $\alpha$-acid, 11·57 per cent. $\beta$-resins, respectively. These were the highest analyses for this variety. Through some misconception samples of the varieties "Northern Brewer" (WFB135)

and Early Promise (X35) were placed in Class 1 instead of in Class 2.

The samples of Pride of Kent (170*a*) placed first and second gave analyses of 6·21 per cent. α-acid, 12·62 per cent. β-resins and 6·32 per cent. α-acid, 12·23 per cent. β-resins respectively. Three other samples of this variety, grown in Kent, were shown; these gave 7·21 per cent., 6·42 per cent., 6·08 per cent. α-acid and 12·95 per cent., 12·36 per cent., 12·36 per cent. β-resins. These figures show that the variety Pride of Kent ripens its crop well in a wet, sunless season such as that of 1951; the consistently high percentage of β-resins characteristic of this variety becomes a point of economic importance now that it has been shown[1] that β-resins possess preservative properties. The highest analyses in this Class were given by Northern Brewer, ranging from 8·96 per cent. to 7·27 per cent. α-acid, 10·73 per cent. to 9·22 per cent. β-resins, and by John Ford, ranging from 8·10 per cent. to 7·26 per cent. α-acid, 10·43 per cent. to 9·42 per cent. β-resins; these analyses (together with many in Class 1) exceed any given for the year by ordinary English commercial varieties. The demand, both in this country and abroad, for Northern Brewer greatly exceeds the present supply. We have permission to quote the following Report received from Dr. B. D. Hartong, N. V. Phoenix Brouwerij, Amersfoort, Holland: "Since two years we have used the new variety "Northern Brewer". Our Brewery is specialized in the production of tropical-proof export lagers and with the said hops we get a very fine flavour in our beer. Also the economy of this type of hops is very attractive because of its very high α-resin contents." At present only 12·2 acres of "Northern Brewer" are planted in this country; the Hops Marketing Board has now decided that this variety shall be valued on the same basis as Goldings and an extension of the acreage can now be expected.

The samples of "John Ford" and "Northern Brewer", exhibited by J. F. Bomford, Ltd., were picked by machine; it is noteworthy that these gave a higher analysis than the hand-picked samples of other growers.*

In Class 3 two samples of Keyworth's Midseason (OR55) gave the high analyses of 6·76 per cent. and 6·33 per cent. α-acid. The growth of "OT48" exhibited by Mr. Brian H. Day proved to be wrongly named, as all the four pockets contained hops possessing

* See, however, this Report, pp. 52 and 54.

an American aroma, whereas the true OT48 (Bramling Cross) has an English aroma.

REFERENCE

[1] D. O. WILLIAMS and J. TODD. 1951. "Humulone Content and Preservative Value of Hops." *Journ. Inst. Brewing*, LVII, 450.

TABLE I

ENTRIES FOR BREWERS' CHALLENGE CUP, 1951.

| Variety and Grower | Parish | Hops moisture-free | |
|---|---|---|---|
| | | α acid % | β fraction % |
| *Northern Brewer* (WFB135). | | | |
| H. Veall | Capel, Kent | 8·05 | 9·46 |
| *Bullion Hop* (Q43) | | | |
| †Furnace Farms, Ltd. | Lamberhurst, Kent | 7·99 | 11·57 |
| *E. M. Gorst | Brenchley, Kent | 7·91 | 10·81 |
| Wm. Rogers & Son | Horton Kirby, Kent | 7·60 | 11·46 |
| Little Fowle Hall, Ltd. | Yalding, Kent | 7·18 | 11·20 |
| J. A. Worley | Chart Sutton, Kent | 6·54 | 10·37 |
| T. E. Wimshurst | Brenchley, Kent | 6·47 | 10·18 |
| J. Nott | Tenbury, Worcs. | 5·87 | 9·67 |
| E. R. & N. M. Edmonds | Cradley, Worcs. | 5·34 | 10·30 |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 5·14 | 8·28 |
| W. Chambers & Son (Kent), Ltd. | Langley, Kent | 4·61 | 9·68 |
| *Brewer's Gold* (C9*a*). | | | |
| H. Veall | Capel, Kent | 6·96 | 9·52 |
| J. A. Worley | Chart Sutton, Kent | 6·56 | 10·73 |
| S. C. & J. H. Berry, Ltd. | Boughton-under-Blean, Kent | 6·45 | 8·65 |
| E. L. Worsfold | East Sutton, Kent | 6·40 | 10·14 |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 6·36 | 8·15 |
| A. & K. J. Amos | Wye, Kent | 6·11 | 8·43 |
| Wm. Skinner & Son | East Sutton, Kent | 6·07 | 9·39 |
| R. D. Wickham | Brenchley, Kent | 6·01 | 9·03 |
| Kennington Hall Farms | Wye, Kent | 5·95 | 7·91 |
| *College Cluster* (N15 *bis*). | | | |
| J. F. Bomford, Ltd. | Fladbury, Worcs. | 6·51 | 7·28 |
| *Malling Midseason* (BB28). | | | |
| Little Fowle Hall, Ltd. | Yalding, Kent | 6·33 | 11·96 |
| *Early Promise* (X35). | | | |
| W. Chambers & Son (Kent), Ltd. | Southfleet, Kent | 5·91 | 8·08 |
| *OK*40. | | | |
| J. F. Bomford, Ltd. | Fladbury, Worcs. | 5·31 | 8·23 |

* Awarded Cup. † Placed second.

TABLE 2

ENTRIES FOR GROWERS' CHALLENGE CUP, 1951.

| Variety and Grower | Parish | Hops moisture-free | |
|---|---|---|---|
| | | α acid % | β fraction % |
| *Northern Brewer* (WFB135). | | | |
| J. F. Bomford, Ltd. .. | Fladbury, Worcs. | 8·96 | 10·30 |
| J. Nott .. .. .. | Tenbury, Worcs. | 8·23 | 10·73 |
| A. & K. J. Amos .. .. | Wye, Kent | 7·44 | 9·22 |
| A. Guinness, Son & Co., Ltd. | Teynham Kent | 7·27 | 9·75 |
| *John Ford* (WFA90). | | | |
| J. F. Bomford, Ltd. .. | Fladbury, Worcs. | 8·10 | 9·42 |
| T. E. Wimshurst .. .. | Brenchley, Kent | 7·53 | 10·09 |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 7·26 | 10·43 |
| *Pride of Kent* (170*a*). | | | |
| H. Veall .. .. .. | Capel, Kent | 7·21 | 12·95 |
| T. E. Wimshurst .. .. | Brenchley, Kent | 6·42 | 12·36 |
| †W. Chambers & Son (Kent) Ltd. .. .. .. | Sevenoaks, Kent | 6·32 | 12·23 |
| *A. & K. J. Amos .. .. | Wye, Kent | 6·21 | 12·62 |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 6·08 | 12·36 |
| *Early Promise* (X35) | | | |
| Little Fowle Hall, Ltd. .. | Yalding, Kent | 6·62 | 7·79 |
| W. Chambers & Son (Kent), Ltd. .. .. .. | Hunton, Kent | 5·81 | 8·38 |
| Wm. Skinner & Son .. | East Sutton, Kent | 5·67 | 7·98 |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 5·54 | 7·20 |
| T. G. Redsell .. .. | Boughton-under-Blean, Kent | 5·47 | 7·17 |
| R. D. Wickham .. .. | Brenchley, Kent | 5·20 | 7·55 |
| *Concord Hop* (OH44). | | | |
| W. Rogers & Son .. .. | Horton Kirby, Kent | 6·58 | 8·14 |
| *Sunshine Hop* (V94). | | | |
| J. F. Bomford, Ltd. .. | Fladbury, Worcs. | 4·96 | 9·28 |
| *WFG*19. | | | |
| A. Guinness, Son & Co., Ltd. | Teynham, Kent | 4·20 | 9·82 |

* Awarded Cup. † Placed second.

TABLE 3

ENTRIES FOR HOP MERCHANTS' ASSOCIATION'S CHALLENGE CUP, 1951.

| Variety and Grower | Parish | Hops moisture-free | |
|---|---|---|---|
| | | $\alpha$ acid | $\beta$ fraction |
| *Keyworth's Midseason* (OR55) | | | |
| E. M. Gorst .. .. .. | Brenchley, Kent | 6·76 | 8·09 |
| *H. J. Highwood, Ltd. .. | Horsmonden, Kent | 6·33 | 8·03 |
| E. Wickham & Son .. | Goudhurst, Kent | 5·71 | 8·09 |
| D. H. J. Britcher .. .. | Yalding, Kent | 5·22 | 7·39 |
| *Bramling Cross* (OT48). | | | |
| B. H. Day .. .. .. | Marden, Kent | 5·57 | 8·24 |

* Awarded Cup.

# NOTES ON PUBLICATIONS

E. S. Salmon: "Bramling Cross." A new Hop resistant to *Verticillium* Wilt. Leaflet. Wye College, Kent. May, 1951. Price 2s.

In the Annual Report for 1949 of the Department of Hop Research, p. 55, a review was given of the Leaflet "Two New Hops resistant to *Verticillium* Wilt", issued from Wye College in January, 1949. It was pointed out that the devastating disease known as "Progressive Wilt" (to distinguish it from a minor disease called "Fluctuating Wilt") has in many cases made the growing of Hops in certain gardens impossible over a wide area around Paddock Wood, Kent. Considerably over 100 Farms have been affected and the disease continues to spread annually. While all the old established varieties have proved to be susceptible, the researches of Dr. W. G. Keyworth and his co-workers at East Malling Research Station have shown that certain of the New Varieties raised at Wye College possess definite degrees of resistance. In the 1949 Leaflet a description was given of the two resistant varieties "Keyworth's Midseason" (OR55) and "Keyworth's Early" (OJ47). Through assistance given by the Hops Marketing Board these varieties were propagated on a large scale and rooted sets made available to those growers whose gardens are Wilt-affected; 217 acres of "Keyworth's Midseason" and 55 acres of "Keyworth's Early" have now been planted.

The present Leaflet describes the third variety which has been found, in tests carried out at East Malling Research Station, to be resistant. This variety, raised in 1927 at Wye College by "crossing" the English variety Bramling with pollen from the Seedling Male Hop (OL45) of Canadian ancestry,* has been named "Bramling Cross"; its botanical and cultural characteristics are given, together with reproductions of photographs taken by Mr. H. H. Glasscock, of the N.A.A.S. Particulars are given of brewing trials, carried out by Messrs. Wm. Younger & Co., Edinburgh. It may be pointed out that while "Keyworth's Midseason" and

* This Male Hop has recently been found to be resistant to Wilt.

" Keyworth's Early " have a higher Preservative value than " Bramling Cross ", they have an aroma belonging to the American class, while " Bramling Cross " has an English aroma.

" Bramling Cross " has now been planted on a small scale on eight farms ; rooted sets (in small quantity) can be obtained from Wye College and over twenty applications have been received for 1952.

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